W.O.S. Personal.

BLASTING ACCESSORIES

PERMISSIBLE
SINGLE SHOT BLASTING UNIT

TN
279
.E54
1925

U PONT DE NEMOURS & CO., INC.
WILMINGTON, DELAWARE

TN
279
.E54
1925

DU PONT EXPLOSIVES SERVICE

EXPLOSIVES must not only be properly made. They must also be properly stored, carefully handled, and properly used. In the course of the one hundred and twenty-three years that the du Pont Company has been engaged in the manufacture of explosives, it has gained a wide knowledge of the storage, handling and use of explosives and it makes a practice of freely sharing this knowledge with its customers.

To this end the du Pont Company issues a series of Explosives Service Bulletins and maintains a staff of technically trained men with practical experience in the use of explosives who give to its customers expert advice concerning storage conditions and blasting operations.

To the end of promptly supplying explosives wherever they are needed, this Company maintains branch offices, mills and magazines throughout the country.

Thus the phrase, du Pont explosives service, denotes, specifically, prompt delivery and technical assistance. When you buy du Pont explosives, you buy these advantages also.

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BLASTING ACCESSORIES
ASSURE
MAXIMUM
EFFICIENCY
WITH
EXPLOSIVES

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WILMINGTON, DELAWARE

DU PONT

BLASTING ACCESSORIES

A Description of the Various Accessories Needed for Firing Charges of Explosives together with Some Explanation of the Best Methods of Using These Accessories

E. I. DU PONT DE NEMOURS & CO., Inc.
EXPLOSIVES DEPARTMENT
WILMINGTON DELAWARE

DU PONT

Blasting Accessories

THE selection of the explosive most suitable for the work in hand demands first consideration in preparing for any blasting operation, but the fact must not be overlooked that no explosive can be fired in such a manner as to develop its full strength without certain materials and appliances especially designed for this purpose. In addition to these appliances and materials necessary to develop the energy of a charge of explosives, there are other devices which, although they may not be absolutely requisite, contribute to safety, certainty and economy in the use of explosives. All these materials, appliances and devices are called "blasting accessories."

The importance of using dependable blasting accessories cannot be overestimated. Accessories of the best grade cost very little in comparison with the explosives, the drilling of the holes and other preparations for the shot. It is therefore expensive to employ inferior firing agents for their use always involves considerable waste of explosives and may result in poor breakage or dangerous and costly misfires.

Du Pont blasting accessories are thoroughly dependable. Laboratory research, exacting care in manufacturing processes, rigid tests of finished products and continuous observation of performance in the field have combined to develop accessories which can be relied upon to perform efficiently the work for which they are designed.

Classes of Explosives and Means by Which They Are Fired

According to the manner in which they explode or are converted into gases, explosives are divided into two general classes—deflagrating explosives and detonating explosives. The explosion of deflagrating explosives consists of a very rapid progressive burning and is initiated simply by a spark or flame. The explosion of detonating explosives consists of an instantaneous decomposition and rearrangement of molecular structure and is initiated by a combination of shock and intense heat. The principal deflagrating explosive is blasting powder. The detonating explosives, or high explosives as they are commonly called, include all the dynamites whether of the nitroglycerin, nitrate of ammonia, gelatin or nitro-starch type, and the Judson powders.

In blasting operations deflagrating explosives are fired by means of sparks furnished by the spit from an electric squib, safety fuse or a miner's squib. Explosives of this class may also be fired by any of the means intended for exploding detonating explosives but, as a rule, such methods of igniting deflagrating explosives are not economical. Large charges of deflagrating explosives, however, are frequently fired by means of a primer of some detonating explosive.

Detonating explosives are not fired by sparks or flame but require some powerful intermediate agent which will deliver a sharp shock, such as a blasting cap, an electric blasting cap or cordeau. These agents are called detonators.

The Advantages of Using Strong Detonators

To obtain the best results from a charge of high explosives, it must be detonated completely, that is, the entire bulk of the explosive must be converted instantly into gases. With complete detonation the maximum force is exerted against the walls of the bore hole and the minimum of flame is produced—this latter being a point of first importance in regard to the detonation of an explosive in the presence of inflammable gas or coal dust. If the detonation is incomplete, the blow struck is always less powerful, more flame is produced, a portion of the charge may burn in the bore hole and large volumes of poisonous gases may be evolved—a matter of serious consequence when the work is underground.

Now to secure complete detonation, a strong, sharp initial shock is necessary. Strong detonators naturally deliver a stronger, sharper initial shock than weaker ones and therefore the stronger the detonator, the more effective the detonation of the explosive.

The No. 6 detonator is now the standard minimum strength detonator in this country. It is ordinarily strong enough for firing charges of moderate size and is used satisfactorily in most kinds of mining, in stumping, ditching and other agricultural work and in a great variety of miscellaneous small blasting operations. However, the initial shock of a detonator does not extend indefinitely through a charge of high explosives with undiminished violence but decreases with distance. Consequently, to secure the most effective detonation of a large charge, as in a well-drill hole, for instance, it is necessary to provide a very strong shock, either by means of No. 8 detonators, which are nearly twice as strong as No. 6, or of cordeau, which extends the detonating charge, and hence the shock, along the entire length of the explosive in the bore hole. The latter is now very widely employed. If electric blasting caps are used in deep holes, several primers will be required. With No. 8 caps, they should be not farther apart than thirty feet and with the lower strengths of less sensitive explosives it is better to have them closer to each other. The No. 8 detonators should also be used in all tunnel driving, in all submarine blasting, and in all operations using large charges of gelatin dynamite, which although very powerful, is relatively insensitive.

The stronger detonators also provide a partial safeguard against trouble with explosives which have begun to deteriorate. As shipped by the manufacturer, explosives are ordinarily of full strength and sensitiveness but if kept too long or stored under improper conditions they are likely to become weaker and less sensitive, consequently harder to detonate. If decrease in sensitiveness has not progressed too far, strong detonators will overcome it and prevent misfires. Likewise, if storage conditions are not of the best, it is wise to buy detonators with a margin of strength to provide against possible deterioration of the detonator charge, which is weakened by moisture. This is especially true of blasting caps, which are affected by dampness more quickly than electric blasting caps because they are open at one end.

The cost of detonators is so small in comparison with that of the charge of explosives and of drilling the holes that it is difficult to understand why any one, in order to save a few cents on the price of a detonator, would risk the misfire, partial detonation or imperfect work of the charge of explosives in a bore hole which would result at best in the loss of several dollars and might cost thousands if a large quarry shot should be spoiled or if unexploded dynamite should happen to cause a fatal accident. All the experience of explosives manufacturers with their products in the field and all the studies and tests conducted by the United States Bureau of Mines go to prove the wisdom and economy of blasting with strong detonators and both the manufacturers and the Bureau of Mines therefore urge their use.

To summarize, strong detonators should always be used with high explosives because they give greater assurance of complete detonation and thus increase the execution of the explosive, reduce fumes to a minimum, decrease the size and duration of the flame, and prevent the loss of the charge by burning. Strong detonators also tend to counterbalance careless and improper practices in loading, priming and tamping and offset to some extent, deterioration of explosives and detonators caused by improper storage, thus reducing the chances of misfires.

Blasting with Cap and Fuse

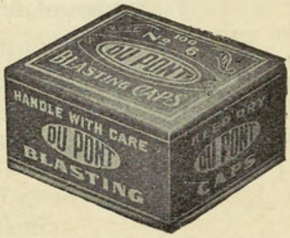
Blasting Caps

Blasting caps are small drawn copper cylinders, closed at one end and loaded with a small charge of a very sensitive and violent explosive that is exploded by the spit of sparks from safety fuse.

Blasting caps and safety fuse may be used to detonate high explosives when it is not desired to fire a number of charges simultaneously. However, when it is desirable for two or more charges to explode at the same moment, electric detonators are required, and under various other conditions electric blasting, which is discussed on pages 23-62, has numerous advantages over the cap and fuse method.

Du Pont Blasting Caps are manufactured in two sizes, No. 6 and No. 8. The No. 8 cap contains nearly twice as much explosive as the No. 6 and is nearly twice as strong.

A No. 7 blasting cap is intermediate in strength between Nos. 6 and 8, but as one of these two numbers is adaptable to all general classes of blasting, the No. 7 strength is not recommended and is furnished only on special factory order.

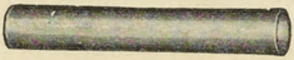


METAL BOX CONTAINING 100 No. 6 DU PONT BLASTING CAPS

Dimensions of du Pont Blasting Caps

	No. 6	No. 8
Outside Color of Box	Red	Green
Length of Copper Shell	1½″	2$\frac{11}{32}$″
Outside Diameter of Copper Shell	.234″	.239–.24″

NOTE.—The *inside* diameter of both the No. 6 and the No. 8 du Pont Blasting Cap is .2205″



No. 6 DU PONT BLASTING CAP

No. 8 DU PONT BLASTING CAP

Both the explosive charge and the copper shells for du Pont Blasting Caps are manufactured with the greatest care and a certain percentage of the loaded caps is regularly tested in order to make sure that they are efficient detonators.

Blasting caps should be stored in a dry place. When conveying them to the work where they are to be used no moisture whatever should be permitted to get into the charge which they contain, as this charge is very quickly affected by dampness, and will absorb moisture and deteriorate. Storage in damp places, such as open sheds or tool boxes in mines, is likely to affect the charge in blasting caps, and may weaken them to such an extent that they will not properly detonate high explosives.

The methods of attaching the blasting cap to the fuse, and of priming high explosive cartridges with the blasting cap and fuse, are described on pages 18-23.

Packages of du Pont Blasting Caps for Domestic Shipment

All blasting caps are packed in tin boxes, each containing 100. Ten boxes are in turn packed in cartons and the cartons, with sawdust, in wooden shipping cases.

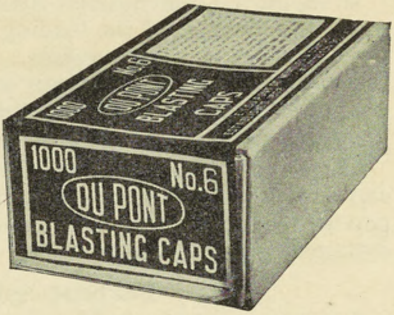
Gross Weight of Packages
No. 6 Blasting Caps

No. of Case	Quantity per Case	In Oblong Boxes
0	500	6 pounds
1	1000	10 "
2	2000	17 "
3	3000	25 "
5	5000	41 "
10	10000	89 "

No. 8 Blasting Caps

0	500	10 pounds
1	1000	16 "
2	2000	30 "
3	3000	41 "
5	5000	63 "
10	10000	129 "

It will be seen that with the exception of case No. 0 the number of the case indicates the number of thousands of blasting caps in the case. As no cases contain 4000 caps, there is no No. 4 case.



CARTON OF BLASTING CAPS

In each box of blasting caps there is a small card known as the "follow-up" card or inspector's ticket. In case trouble is experienced with the blasting caps this ticket, with any unused blasting caps, should be preserved in order to facilitate investigation.

Safety Fuse

Safety fuse is the medium of bringing sparks to fire blasting caps or to ignite a charge of blasting powder. It is made up of a thin train of powder tightly compressed in inner and outer wrappings of jute, cotton or tape with waterproofing material between them.

Brands of Fuse

The different kinds of safety fuse made may be grouped into four classes according to whether they are intended for dry work, damp work, wet work or under water work. The classification of brands of fuse sold by the du Pont Company according to this standard is:

DRY WORK	DAMP WORK	WET WORK	UNDER WATER
	Beaver (a) (1)	Charter Oak (Gray) (a) (2)	Crescent (a) (1)
	Charter Oak (White) (a) (2)	Victor (c) (2)	Clover (a) (2)
Cotton (a) (1)	Sylvanite (b) (2)	Bear (d) (2)	Pacific (c) (2)
	Blue Label (c) (2)	Dreadnaught (c) (2)	Eclipse Special (c) (2)
	Single Tape*	Monarch (White and Black) (b) (2)	Sequoia (c) (2)
		Double Tape*	

(a) Sold in the States east of Montana, Wyoming, Colorado and New Mexico or the Eastern States.
(b) Sold in the States of Montana, Wyoming, Colorado and New Mexico or the Middle West States.
(c) Sold in the States west of North Dakota, Wyoming, Colorado and New Mexico or the Western States.
(d) Sold west of and including Montana, Wyoming, Colorado and New Mexico.
(1) Standard burning speed 90 seconds per yard subject to 10% variation.
(2) " " " 120 " " " " " 10% "
* Sold in all States. Taped fuses manufactured by the Ensign-Bickford Co. for the Eastern States are on the 90 second per yard standard. All others are on the 120 second standard.

It should be remembered that in all classes of blasting where water is encountered the loading should be done quickly and the shots fired as soon as possible. While the brands listed for use under water will burn through water when first loaded, they will not withstand wetting for a long time, especially when under pressure of several feet of water.

Cotton fuse is too small in diameter to fit the standard blasting cap properly, and should be used only for igniting blasting powder charges, where a blasting cap is unnecessary unless a dynamite primer is used.

Burning Speed of Fuse

Safety fuse sold in the Eastern States burns, in the open, at the rate of about thirty-two seconds per foot, except Charter Oak, Gray Charter Oak and Clover brands, which have a burning speed, in the open, of about 40 seconds per foot; that sold in the Middle Western and Western States burns at the rate of between 36 and 39 seconds per foot. This burning speed is subject to a variation of 10 per cent either way. Fuse burns faster when tightly tamped. The length of fuse used in a blast must always be long enough for the blaster to retire to a safe distance.

Safety Fuse Packages

Safety fuse is manufactured in lengths of 50 feet. Each length is made into a roll, two rolls are fitted together, one inside the other, and neatly wrapped in paper. The double rolls are packed in wooden cases.

Each fuse wrapper is stamped with a serial number, which, with the markings on the packing case, should be preserved in case trouble is experienced with the fuse, for identification and to facilitate investigation.

Capacity, Dimensions and Approximate Gross Weights of Cases of Fuse Made by the Ensign-Bickford Company

Brand	No. 0 Fiber Case 500 Ft. Tare 1 Lb.	No. 1 Fiber Case 1000 Ft. Tare 2 Lbs.	No. 2 Fiber Case 2000 Ft. Tare 4 Lbs.	No. 3 Fiber Case 3000 Ft. Tare 5 Lbs.	No. 4 Wood Case 4000 Ft. Tare 17 Lbs.	No. 5 Wood Case 5000 Ft. Tare 18½ Lbs.	No. 6 Wood Case 6000 Ft. Tare 20 Lbs.
Cotton	5½	10½	22	30	48	60	70
Single Tape	8½	16	31	46	75	91	105
Double Tape	8½	17½	35	50	79	96	114
Beaver Brand	8½	16	33	48	75	91	107
Charter Oak Brand	8½	16	32	47	75	91	107
Gray Charter Oak Brand	8½	17½	33½	49½	77	93½	110
Clover Brand	9	17½	35	51	81	98½	114
Anchor Brand Crescent Brand	8½	17	33	47	75	91	107

NOTE: Tare on Cotton No. 4, No. 5 and No. 6 is 13 lbs., 16 lbs., and 17 lbs., respectively.

NOTE: As weights of fuse vary slightly at different seasons of the year, it is well when ordering a minimum carload to so specify on the order.

OUTSIDE DIMENSIONS OF WOODEN CASES

Domestic	Tare
6000 ft. case 27½ x 20½ x 14½″	20 lbs.
5000 ft. case 24 x 20½ x 14½″	18½ lbs.
4000 ft. case 20 x 20½ x 14½″	17 lbs.
3000 ft. case 21 x 14¼ x 14¼″	13 lbs.
2000 ft. case 15 x 13¾ x 13½″	6 lbs.
1000 ft. case 14¾ x 13¾ x 7″	4 lbs.
500 ft. case 14¾ x 7¾ x 7″	2½ lbs.

OUTSIDE DIMENSIONS OF FIBER CASES

Domestic	Tare
3000 ft. case 18¾ x 12½ x 13½″	5 lbs.
2000 ft. case 13¼ x 12¼ x 12¼″	4 lbs.
1000 ft. case 13¼ x 12¼ x 6⅛″	2 lbs.
500 ft. case 13¼ x 6⅛ x 6⅛″	1 lbs.

Capacity, Dimensions and Approximate Weights of Packages of Fuse Made by the National Fuse & Powder Company

Case No.	Capacity Feet	Wood Cases			Fiber Cases		
		Gross Wt. Lbs.	Tare Wt. Lbs.	Net Wt. Lbs.	Gross Wt. Lbs.	Tare Wt. Lbs.	Net Wt. Lbs.
		Sylvanite—Single Tape					
0	500	10	3½	6½	7¼	¾	6½
1	1000	17½	4½	13	14½	1½	13
2	2000	34½	8½	26	28¼	2¼	26
3	3000	50¼	11¼	39	43¾	4¾	39
6	6000	102	24	78			
		Double Tape, Bear					
0	500	10¾	3½	7¼	8	¾	7¼
1	1000	19	4½	14½	16	1½	14½
2	2000	37½	8½	29	31¼	2¼	29
3	3000	54¾	11¼	43½	48¼	4¾	43½
6	6000	111	24	87			
		Monarch					
0	500	10½	3½	7	7¾	¾	7
1	1000	18½	4½	14	15½	1½	14
2	2000	36½	8½	28	30¼	2¼	28
3	3000	53¼	11¼	42	46¾	4¾	42
6	6000	108	24	84			

Outside Dimensions (in Inches) All Brands

Case No.	Capacity Feet	Wood Cases	Fiber Cases
0	500	8¼ x 8¼ x 13½	7¼ x 7¼ x 11
1	1000	8¼ x 12¼ x 15¾	14½ x 7¼ x 11
2	2000	8¼ x 15¼ x 24	14½ x 14½ x 11
3	3000	7¾ x 15¼ x 31¼	22 x 14½ x 10½
6	6000	14 x 15½ x 36½	

Capacity, Dimensions and Approximate Weights of Packages of Fuse Made by the Coast Manufacturing & Supply Company

	WOODEN CASE 6000 ft. case			WOODEN CASE 3000 ft. case			WOODEN CASE 1000 ft. case			FIBER CASE 3000 ft. case			FIBER CASE 1000 ft. case			FIBER CASE 3000 ft. reel		
	Gross	Tare	Net	Gross	Tare	Net	Gross	Tare	Net	Gross	Tare	Net	Gross	Tare	Net	Gross	Tare	Net
Double Tape	109	18	91	56	13½	42½	21	6½	14½	48	4	44	16½	1½	15	52	4	48
Bear	113	18	95	58	13½	44½	22	6½	15½	50	4	46	17	1½	15½	54	4	50
Victor	107	18	89	55	13½	41½	21	6½	14½	47	4	43	16	1½	14½	51	4	47
Pacific	101	18	83	52	13½	38½	20	6½	13½	44	4	40	15	1½	13½	48	4	44
Blue Label	106½	18	88½	55	13½	41½	21	6½	14½	47	4	43	16	1½	14½	50½	4	46½
Eclipse Special	107½	18	89½	55	13½	41½	21	6½	14½	47½	4	43½	16	1½	14½	51	4	47
Dreadnaught	103	18	85	53	13½	39½	20½	6½	14	45	4	41	15½	1½	14	49	4	45
Sequoia	112½	18	94½	57½	13½	44	22	6½	15½	50	4	46	17	1½	15½	53½	4	49½

OUTSIDE DIMENSIONS OF WOODEN CASES

Domestic	Tare
6000 ft. case 34 x 14 x 14″	18 lbs.
3000 ft. case 21¼ x 13¼ x 11″	13½ lbs.
1000 ft. case 12¼ x 14 x 7½″	6½ lbs.

OUTSIDE DIMENSIONS OF FIBER CASES

Domestic	Tare
3000 ft. case 19¾ x 12⅞ x 10⅞″	4 lbs.
1000 ft. case 13¼ x 10½ x 6¾″	1½ lbs.
3000 ft. reel 15 x 13½ x 13½″	4 lbs.

EXPORT

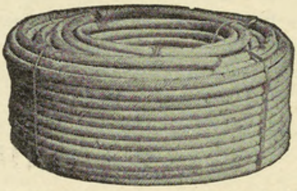
6000 ft. case 32 x 14 x 14″ 18 lbs. with paper lining.

Each case of fuse is plainly marked with our standard serial date number indicating the month and year in which contents were manufactured. Example: January, 1925-41, July 1925-35, January 1926-97, etc.

Storage and Handling of Fuse

Safety fuse cannot be kept in good condition unless stored in a *cool, dry* place. If stored in a hot place, the heat is likely to melt the waterproofing material, causing it to penetrate to the powder core or making the fuse too soft; or the heat may dry out the fuse so that it will break when unrolled. If stored in a damp place, the powder in the fuse soon absorbs moisture and fails to burn properly.

When handling safety fuse, do not twist or "kink" it. Always cut off at least two inches of the end of the coil and insert the fresh cut end of the fuse in the blasting cap, because the powder in the end becomes damp and ineffective very quickly. It is also likely to spill out of the cut end after the fuse has been handled a little. In either case a misfire might occur.


DOUBLE ROLL OF SAFETY FUSE WITH PAPER WRAPPING REMOVED

Always cut the end of the safety fuse which is to be inserted in the blasting cap squarely across and not diagonally. The point made by a diagonal cut may be bent forward when the safety fuse is pushed into the blasting cap, and in this way prevent the spark from shooting into the blasting cap charge.

Always press the end of the safety fuse gently against the charge in the blasting cap before crimping the blasting cap. All safety fuse, except Cotton, is made to fit as snugly as possible into the blasting cap in order to prevent water or moisture from entering. If the safety fuse is found at any time to be a little too large to enter the blasting cap, do not attempt to cut off any of the tape or yarn, but squeeze or roll the end between the thumb and finger until it is small enough.

It occasionally happens that when subjected to summer heat the waterproofing of some kinds of fuse will absorb the white material put on the outside, causing it to appear black or of a dingy yellow color. This unfavorable appearance does not necessarily indicate that the fuse is damaged. It is probably perfectly good, but it should be tested, and this will readily determine its condition.

If fuse is stored too long, it may become dry and hard, or the powder may be impaired by age.

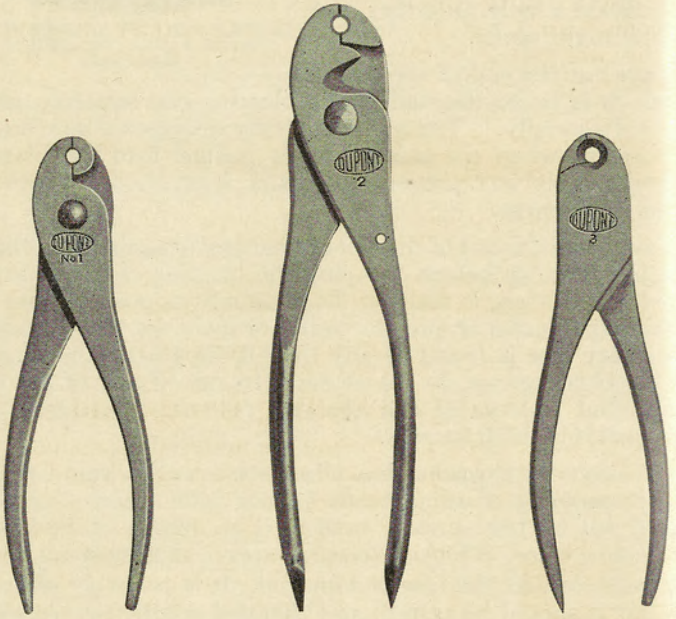
In tape fuse, places may be found where the diameter is slightly enlarged for about an inch in length. This is caused by the overlapping of the ends of the tape where two pieces are sewed together. It does not indicate any defect in the fuse.

Cap Crimpers

When using blasting caps and safety fuse, it is essential that the blasting caps be securely fastened or crimped to the fuse. If the joining is not firm, there is danger that the fuse will be pulled out when the primed cartridges are loaded and the bore holes tamped. An imperfect joining makes the waterproofing of the cap difficult. The most satisfactory crimp can be made by using a cap crimper,—an instrument designed for the purpose.

The No. 1 and No. 2 du Pont Cap Crimpers make a flat sleeve crimp which holds the cap securely on the fuse and makes waterproofing possible with but a small amount of waterproofing material.

Du Pont Cap Crimpers are all made of steel, nickel plated. The No. 1 Crimper is 5½ inches long and has one handle pointed for use as a punch in priming dynamite cartridges.



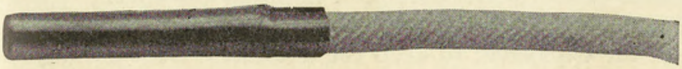
No. 1 No. 2 No. 3

DU PONT CAP CRIMPERS

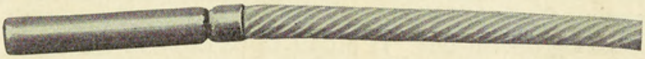
The No. 2 Cap Crimper is 7 inches long. In addition to the crimper, it is provided with a most effective fuse-cutting device, so designed as to prevent accidental cutting of blasting caps. One handle is pointed for use as a punch and the other has a screwdriver point.

Both of these crimpers are so made that they cannot squeeze the copper shell far enough into the fuse to interfere with the burning of the powder train and cause misfires. They are well made of good material and, if used only for the purposes intended, will give good service for a long time.

The No. 3 du Pont Cap Crimper is the result of several years' experiments to produce a cap crimper which will make a water-tight crimp on a smooth-covered fuse. In many mining conditions the work is so wet that a water-tight joint is necessary between the cap and the fuse, and while a water-tight joint can be made by means of the sleeve-type crimper with the additional use of du Pont Cap Sealing Compound, or a similar dip, it takes some time and care to prepare and dry the dipped caps and fuses properly. With the No. 3 du Pont Crimper a water-tight crimp can be made on a smooth-surfaced fuse. It is, however, necessary, when the No. 3 Crimper is used, that the fuse be cut square across before being inserted in the cap so that it can be seated squarely on the cap composition, for any air space between the end of the fuse and the composition in the cap will result in a certain percentage of failures.



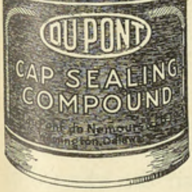
BLASTING CAP CRIMPED TO FUSE WITH NO. 1 OR NO. 2
DU PONT CRIMPER



BLASTING CAP CRIMPED TO FUSE WITH NO. 3
DU PONT CRIMPER

Du Pont Cap Sealing Compound

Du Pont Cap Sealing Compound is a material for sealing water-tight the space between the shell of a blasting cap and the fuse which is inserted into the blasting cap.

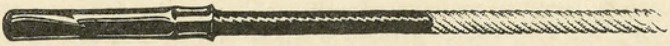


DU PONT CAP
SEALING COMPOUND

Except with the No. 3 Cap Crimper and a smooth-surfaced fuse, it is almost impossible to make a joint that will prevent water from leaking in and spoiling the cap. The cap is especially liable to damage from water when countered fuse is used, because the uneven surface of such fuse formed by the spirally wound cords leaves small air spaces between the fuse and the shell through which water may leak down into the cap. Therefore, if the cap is to come in contact with water and the joint is not watertight, it should be made waterproof by sealing with du Pont Cap Sealing Compound.

After the blasting cap is crimped on the fuse, the cap with two or three inches of the fuse is dipped for a few seconds into the cap sealing compound and hung up to dry. It is not necessary to soak the cap in the compound. By the time the compound has dried for about thirty minutes, a water-tight joint is formed which will resist almost any amount of water commonly encountered in blasting with cap and fuse. The cap should be used soon after it is dry, as the cap sealing compound becomes brittle after a few days and is likely to crack and admit water.

Du Pont Cap Sealing Compound is put up in half-pint, pint, quart and gallon cans.



CAP SEALING COMPOUND APPLIED TO CRIMP

Making Primers with Blasting Caps and Safety Fuse

A high explosive cartridge containing a blasting cap with fuse attached, or an electric detonator is called a primer.

Primers must be properly made to insure the complete detonation of the explosive; to keep the detonator from pulling out of the explosive; to guard against moisture; to permit easy and safe loading of bore holes; to keep the safety fuse, when blasting caps and safety fuses are used, from pulling out of the blasting cap.

Preparing the primer is really one of the most important steps in all blasting operations. It ought to be done in the safest suitable place that can be found, and it should also be done in the manner which is calculated to secure the best results. Yet both of these considerations are frequently violated, and the priming, entrusted to one of the least skilled among the workmen, is done in the magazine where an accidental explosion would be certain to cause widespread disaster, and is also done in a manner just the opposite to that recommended by the manufacturers of explosives and blasting accessories.

Of course, it takes a little longer to make primers in the proper way than it does by the half-hitch method, but the extra time is well spent, and it should be borne in mind that it is the time of *one man*, while the time spent in hunting down trouble is the *combined time of all the men, horses and machinery*. There never yet was a cheap misfire.

Attaching Blasting Cap to Fuse

Cut off a sufficient length of fuse to reach from the charge of explosives loaded in the bore hole to at least three or four inches above the collar or top of the bore hole. In all classes of blasting, the length of the fuse must be governed by the time required for the blaster to reach a safe place after lighting the fuse.

After removing the cover of the blasting cap box, allow a single blasting cap to slide gently into the hand. Never try to pick a blasting cap out of the box with a wire, knife blade, stick, or other hard substance. See that no foreign matter, such as dirt or grit, is in the open end of the blasting cap; if there is any, shake it out gently. If the end of the fuse is flattened, roll it between the thumb and finger to round it out again and slip the blasting cap gently over the end of the fuse so that the fuse reaches down to the explosive charge in the blasting cap.

Do not twist the fuse into the blasting cap, and do not use violence or force when handling the blasting caps or when making primers.

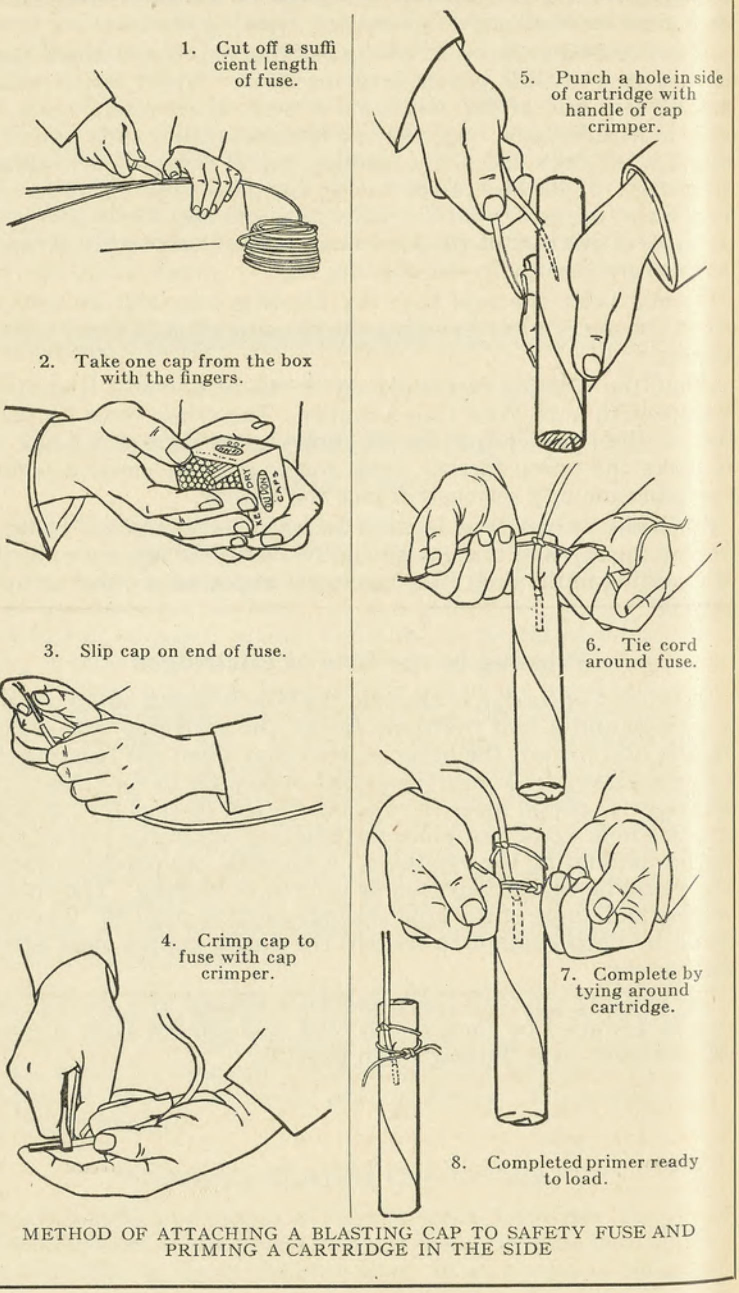
When the blasting cap is placed on the fuse, fasten it securely in place with a du Pont Cap Crimper. The crimp must be made close to the open end of the blasting cap as shown on page 17. To make the crimp farther down might possibly cause a premature explosion and seriously injure the blaster.

When the primer is to be used under water, the union between the blasting cap and the fuse should be protected against moisture by a coating of du Pont Cap Sealing Compound or other suitable material.

Priming in the Side of Cartridges

To prime a cartridge in the side the hole is begun about an inch or an inch and a half from one end of the cartridge, and should point in and toward the other end, so that when the blasting cap is inserted it will be as nearly parallel as possible to the sides of the cartridge. *It should never be punched straight through the cartridge,* as such a hole would not place the blasting cap in the proper position for detonating the explosive. A blasting cap placed in such a hole would be easily displaced or injured in loading. The correct location and angle of the hole are indicated on page 20. The hole should be deep enough to receive the entire copper shell of the blasting cap.

The blasting cap with fuse attached is slipped into the hole and securely fastened by means of a cord tied around both the fuse and cartridge, as is illustrated on page 20.



1. Cut off a sufficient length of fuse.

2. Take one cap from the box with the fingers.

3. Slip cap on end of fuse.

4. Crimp cap to fuse with cap crimper.

5. Punch a hole in side of cartridge with handle of cap crimper.

6. Tie cord around fuse.

7. Complete by tying around cartridge.

8. Completed primer ready to load.

METHOD OF ATTACHING A BLASTING CAP TO SAFETY FUSE AND PRIMING A CARTRIDGE IN THE SIDE

This method of priming in the side has the advantage of leaving more space for placing the tamping stick on the primer, but it cannot be used in such small holes as can the end primers on account of the fuse lying alongside the cartridge and thereby increasing the total diameter. This method does not place the blasting cap in quite so good a position as priming in the end.

Such a primer is waterproofed by covering the joint between the fuse and paper shell with a waterproofing material.

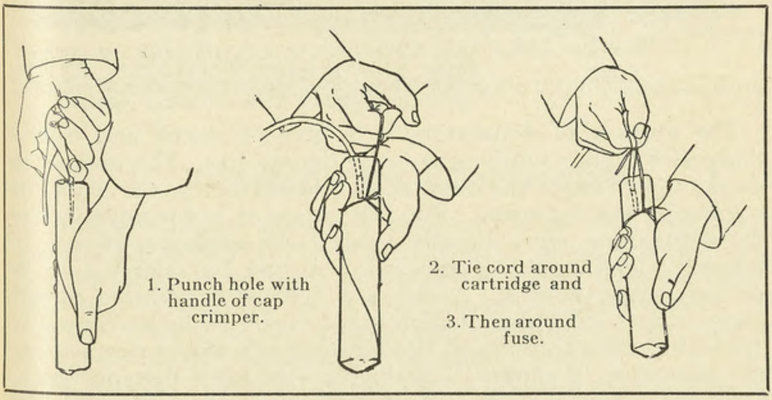
Priming in the Ends of Cartridges

There are two good methods of priming cartridges in the end.

(*a*) With the handle of the cap crimper or a wooden awl, punch a hole straight into the end of the cartridge to a sufficient depth to receive all of the copper shell of the blasting cap and fasten it there by means of a cord tied first around the cartridge and then around the fuse, as is shown below. This is an easily made and highly satisfactory primer.

To waterproof such a primer, close the hole where the fuse enters the cartridge with suitable sealing materials.

(*b*) The other method is to unfold the paper from the end of the cartridge and punch a hole directly into the center of the exposed dynamite, close the loose part of the paper shell around the fuse, and tie it tightly. The process of waterproofing is the same as stated in the preceding paragraph.


1. Punch hole with handle of cap crimper.
2. Tie cord around cartridge and
3. Then around fuse.

PRIMING IN END OF CARTRIDGE

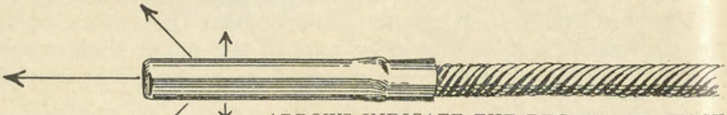
Priming in the end has the advantage of placing the blasting cap or other detonator in the best possible position for detonating the explosives used; but it sometimes has the disadvantage, especially when the bore holes are small, of bending the fuse too sharply and causing it to be scraped or torn, and also of not leaving sufficient room to place the tamping stick on the primer to slip the latter into place in the bore hole.

There are several other methods of making primers, but the three methods described are the only ones that have proved to be safe and reliable.

Fuse should never be laced through cartridges of high explosives, as the powder inside of the fuse may burn through the covering or "side spit" and ignite the dynamite before the cap explodes. This materially reduces the force of the blast.

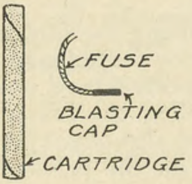
Importance of Position of the Detonator

The force of all explosives is exerted equally in all directions, but blasting caps, electric blasting caps and all other du Pont detonators have copper shells so constructed that the shock from the explosion is greater from the closed end than from the sides. This is the end away from the fuse or wires. This closed end is frequently referred to as the "business end." It should not be understood that all of the shock from an exploding detonator goes out from the end, for such is not the case. There is shock in all directions, but the greatest shock is from the end. The violence of the shock in relation to direction is indicated by the arrows in the following sketch.

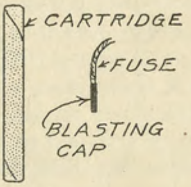


ARROWS INDICATE THE DEGREE OF SHOCK FROM A DETONATOR IN RELATION TO ITS DIRECTION, THE GREATEST SHOCK BEING IN LINE WITH THE LONGEST ARROW

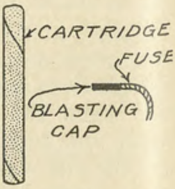
The purpose of detonators is to give off shock and heat to charges of high explosives to cause detonation. The greater the shock, the stronger the detonation and the better the work that is done by the explosive. For this reason it is desirable to have the detonators point directly toward the explosive charge. A better understanding of this may be had by referring to the accompanying figures. A shows a detonator pointing directly away from a cartridge of high explosives. Using an insensitive dynamite, the explosion of the blasting cap would not detonate the explosive. B shows a blasting cap the same distance from a cartridge of high explosives, but pointing parallel to the cartridge. Using the same insensitive dynamite, if this cap caused any detonation at all, it would be incomplete and weak.



A



B

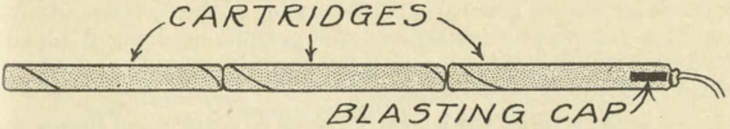


C

C shows the same insensitive dynamite and the blasting cap the same distance away as before, but pointing directly toward the dynamite. In this position the detonation of the dynamite should be complete.

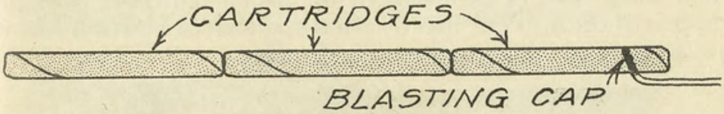
These positions of blasting cap and dynamite are purely demonstration examples to illustrate the principle involved, and should never be attempted in actual work.

In a bore hole a detonator should point, as nearly as possible, directly toward the main portion of the charge of explosives.



SHOWING HOW BLASTING CAP SHOULD POINT WHEN BORE HOLE IS LOADED WITH SEVERAL CARTRIDGES

Were the single blasting cap pointed diagonally across the primer cartridge, as shown below, the shock to, and effect on, the cartridges in the other end of the bore hole would be much less.



PLACING BLASTING CAP DIAGONALLY LESSENS ITS EFFECTIVENESS AS A DETONATOR

Blasting by Electricity

Firing explosives charges by electricity is the most effective and economical system of blasting for it surpasses all others in safety and certainty as well as in results accomplished. Electric blasting makes it possible to fire several charges simultaneously. This always effects economy of explosives and often it is the only possible way to obtain satisfactory results.

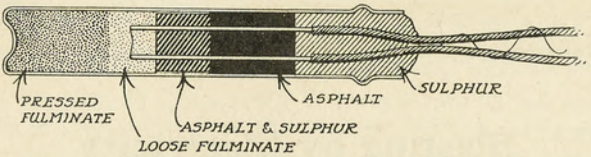
While many kinds of blasting can be accomplished only by electric firing, almost every kind that can be performed by the cap and fuse method can now be executed more safely, quickly and conveniently by electricity. With this method delayed explosions or "hang fires" are hardly possible, and, as the blaster can always be a considerable distance away from the explosive when it detonates, the possibility of accident is reduced to a minimum.

Electric blasting in coal mines deserves more consideration than it has hitherto received, whether the explosive be a permissible or blasting powder. It eliminates the lighting of a fuse or miner's squib, which is dangerous in a gaseous and dusty mine even though a device is used in which no open light is exposed; it does away with the smoke and fumes from burning fuse or squibs; and it removes the chance of ignition of a permissible charge by side spit from fuse. Where the practice of firing several shots at once is employed, electric blasting prevents the possible occurrence of a blown-out shot immediately after several other shots which may have produced gas or stirred up coal dust—an occurrence which is believed to have been responsible for some disastrous explosions in coal mines where the shooting was done with fuse or squibs. Electric blasting is more efficient as well as safer than other methods because it gives greater assurance of the complete detonation of a permissible explosive and permits igniting a blasting powder charge in the center with resultant increase in rate of combustion and decrease of smoke.

In all underground work, the decrease of smoke and fumes with electric blasting is a material advantage. In submarine or other very wet blasting operations, no other system is possible.

Electric Blasting Caps

An electric blasting cap, as the name implies, is a special form of detonator fired or exploded by an electric current. The construction of the du Pont Electric Blasting Cap can be best learned from a study of the accompanying drawing.



SECTIONAL VIEW OF A DU PONT
ELECTRIC BLASTING CAP

The strength of electric blasting caps is governed by the strength and the quantity of the explosive charge contained, and is expressed by the numbers 6 and 8. The No. 8 du Pont Electric Blasting Caps contain nearly twice the charge of the No. 6 and are almost twice as strong. Where large charges of explosives are used in one bore hole the use of a No. 8 Electric Blasting Cap will more than pay for itself in increased execution of the dynamite.

The following table describes fully the two sizes or strengths:

Grade	No. 6	No. 8
Color of Label	Red	Green
Length of Shell	1¾″	2″
Calibre of Shell	.273″	.273″

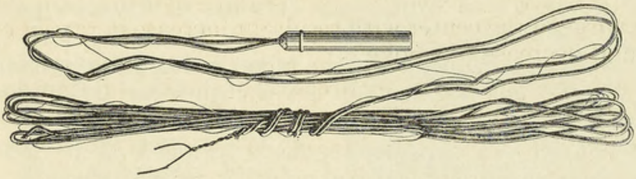
There is also a No. 7 Electric Blasting Cap that is intermediate between Nos. 6 and 8, but as one of these two strengths is adapted to all general work, the No. 7 strength is not recommended and is furnished only on special order.

The blasting cap wires vary in length to suit different depths of bore holes and different classes of work. They must always be long enough to reach a few inches out of the bore hole, and should preferably be long enough to reach to the wires of the adjoining bore holes.

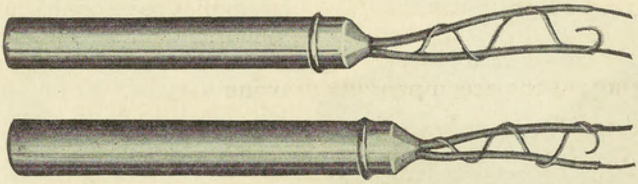
Stock lengths of copper wires are:

4 ft.
6 ft.
8 ft.
10 ft.
12 ft.
14 ft.
16 ft.
18 ft.
20 ft.

Special lengths not listed above will be supplied on special order.



A DU PONT ELECTRIC BLASTING CAP SHOWING WIRES



DU PONT No. 6 and No. 8 ELECTRIC BLASTING CAPS—EXACT SIZE

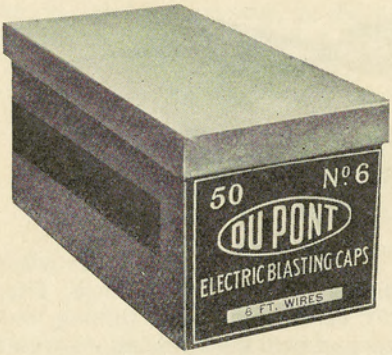
All electric blasting cap wires are well insulated. Copper wires are ordinarily used on account of the low electric resistance. Iron wires are also used to some extent, especially in coal mining, but on account of the electric resistance of iron being about six times as great as that of copper, a blasting machine cannot fire as many electric detonators when iron wires are used as when copper wires are used. (See page 47 for table of wire resistance of electric blasting caps with copper and iron wires.) The standard lengths of iron wires are 4, 6 and 8 feet. Longer lengths will be supplied on special order, but they are not recommended. For general work copper wires are far superior.

All du Pont Electric Blasting Caps for coal mine use are now short circuited to prevent premature explosion through accidental contact with stray currents of electricity such as are present in some sections of most coal mines, coming from poorly bonded rails, electrical machinery with a grounded circuit or similar sources.

By properly twisting the ends of the wires together an electric blasting cap can be short circuited so that it will not explode even if the wires come in contact with electric currents much stronger than those usually found as stray currents. In the du Pont short-circuited cap, the wires are twisted once on the insulation and three times on the tinned ends. This is done by machine and each cap is inspected to see that the twist is regular and tight. It has been demonstrated by test that a 550 volt 25 ampere current applied to the bare ends of these twisted wires will not detonate the cap. The wires simply fuse in the heat that is generated, whereas with wires free so as to give a circuit through the cap, a current of one-third of an ampere and one volt will cause detonation. The short-circuited caps therefore eliminate the danger of premature explosion from stray currents or from contact with electrical machinery.

The proper procedure is for the miner to make the primer, load and tamp the shot and then untwist the wires just before connecting them with the leading wires.

The twisted wire caps are regularly supplied on all orders for coal mines and can be furnished on other orders if desired.



CARTON OF 50 ELECTRIC BLASTING CAPS

Electric blasting caps are packed in pasteboard cartons, which are inclosed in heavy wooden cases. The cartons contain either 25 or 50 electric blasting caps, depending on the length of the wires. Electric blasting caps with wires from 4 feet to 16 feet long are packed 500 to the case, while those with longer wires are packed 250 to the case.

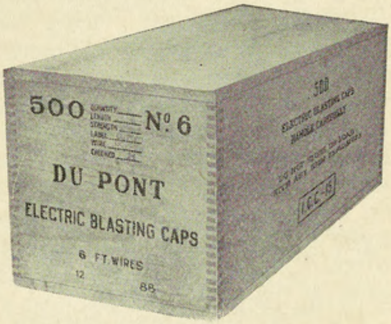
The storage of electric blasting caps should always be given careful attention by the consumer. If they are permitted to remain for a long time in a very warm place, the waterproofing material in the insulation dries out to such an extent that the insulation may break when the wires are bent, and misfires result if an attempt is made to use them in wet work.

The explosive charge in the electric blasting caps is very easily affected by moisture, and if they are stored too long in a damp or wet place they may deteriorate. This charge is also very sensitive, and may be exploded by a moderately hard knock or jar. Electric blasting caps should, therefore, be handled carefully. Careful handling is also necessary on account of the delicate bridge wire (see sectional view of electric blasting cap), which may be broken by rough usage. When this is broken, the electric blasting cap is absolutely useless. The wires must not be bent sharply or forcibly separated at the point where they enter the copper cap, as this may break or loosen the filling material and permit water to enter and damage the explosive charge. These precautions are necessary with all classes of electric detonators.

Care must be taken when tamping the bore hole not to break either the electric blasting cap wires or the insulation on them, or to pull the electric blasting cap out of the primer.

Many misfires are due to carelessness in loading and tamping bore holes.

In each carton of electric blasting caps there is a paper tag called the "follow-up" tag. In case any trouble is experienced with the electric blasting caps, this tag should be preserved, as well as any unused electric blasting caps, and, in addition, the markings on the wooden cases in which the cartons were packed should be recorded.



SHIPPING CASE OF
ELECTRIC BLASTING CAPS

Du Pont Electric Blasting Caps are so constructed as to be highly satisfactory for moist and wet work. They can be used under several feet of water if the time between loading and firing is not too great. They are not intended for use under great heads of water, or for submarine work.

Weights and Dimensions of Electric Blasting Cap Cases

Quantity per Case	Quantity per Carton	Length Feet	Gross Lbs.	Tare Lbs.	Net Lbs.	Outside Dimensions Length Width Depth	Dimensions Cartons
500	50	4′	25	7½	17½	22″x 9½″x9½″	8″x4″x4″
500	50	6′	31	7½	23½	22″x 9½″x9½″	8″x4″x4″
500	50	8′	38	8½	29½	22″x11½″x9½″	10″x4″x4″
500	50	10′	44	8½	35½	22″x11½″x9½″	10″x4″x4″
500	50	12′	53	10	43	22″x15½″x9½″	14″x4″x4″
500	50	14′	59	10	49	22″x15½″x9½″	14″x4″x4″
500	50	16′	66	10¾	55¼	22″x17½″x9½″	16″x4″x4″
250	25	18′	44	10¾	33¼	22″x17½″x9½″	16″x4″x4″
250	25	20′	47	10¾	36¼	22″x17½″x9½″	16″x4″x4″
250	25	22′	50	10¾	39¼	22″x17½″x9½″	16″x4″x4″
250	25	24′	53	10¾	42¼	22″x17½″x9½″	16″x4″x4″
250	25	26′	56	10¾	45¼	22″x17½″x9½″	16″x4″x4″
250	25	28′	59	10¾	48¼	22″x17½″x9½″	16″x4″x4″
250	25	30′	62	10¾	51¼	22″x17½″x9½″	16″x4″x4″

Waterproof Electric Blasting Caps

Although electric blasting cap wires and copper shells are well insulated against water, they are not intended for extremely wet work, and if used in water, particularly under pressure, water may leak into the cap and desensitize the explosive charge or it may penetrate the insulation on the wires and cause the electric current to "short circuit" through the water instead of passing through the bridge wire, which is of high resistance. For such work du Pont Waterproof Electric Blasting Caps have been especially developed. They have a longer shell than electric blasting caps so as to allow more space for waterproofing material above the plug and the wires have an enamel coating so that if water penetrates the cotton insulation it cannot reach the copper. If a long line of holes connected in series is to be shot where the ground water contains even minute quantities of mineral salts, waterproof electric blasting caps should be used although there is no standing water in the holes, for the conductivity of saline water is so great that it may cause sufficient current leakage from wires of ordinary electric blasting caps to cause the misfire of some of the center holes.

Du Pont Waterproof Electric Blasting Caps are made in the same strengths as the electric blasting caps, No. 6 and No. 8, with the same lengths of copper wires. They are not made with iron wires.

DU PONT WATERPROOF ELECTRIC BLASTING CAP

They must be handled with the same care as electric blasting caps. They are packed in cartons, and then in cases of the same size as are used for electric blasting caps. The weights of packages are slightly greater than those of electric blasting caps.

Delay Electric Blasting Caps

In some kinds of blasting, particularly in tunnel and shaft work, it is necessary to blast each round of bore holes in groups or in rotation. It is generally a saving in time if this can be done in such a way as to obviate the necessity of returning to the working face after each group has been blasted to arrange for the next blast. When fuse and blasting caps are used to detonate the explosive, the pieces of fuse for the different bore holes are cut in different lengths so that the charges will explode in the proper

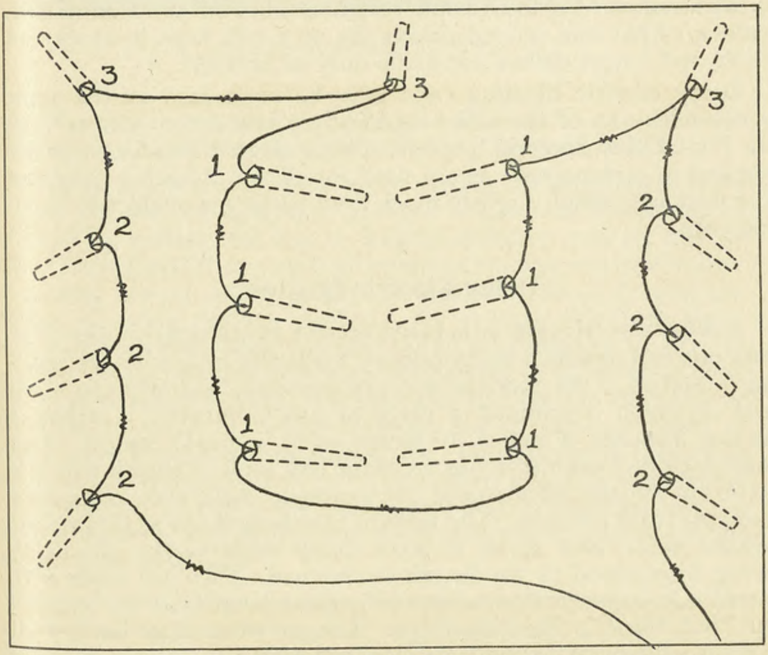
First Delay (Size Reduced). Length of Shell, 1 Inch

Second Delay (Size Reduced). Length of Shell, 1½ Inches
DELAY ELECTRIC BLASTING CAPS

sequence if the fuses are lighted at about the same time. There is practically no limit to the number of charges which can be exploded in sequence with fuse and blasting caps in this way, but electric firing is much more satisfactory for the many reasons of safety and effectiveness pointed out on pages 23-24.

The du Pont Delay Electric Blasting Caps have been developed so that a round of shots may be fired in rotation with a single set of wiring and with but one application of the electric current, and in such a way that there is no trouble from the first relay of shots breaking the wires for successive relays.

Du Pont Delay Electric Blasting Caps are made in five delays. These are so constructed that there is a short interval of time after the current is applied before the first delays explode, a longer interval before the second delays explode, a still longer interval



METHOD OF CONNECTING INSTANTANEOUS, FIRST DELAY AND SECOND DELAY ELECTRIC BLASTING CAPS before the third and so on through the fifth delay. It should not be understood that all delays of any one period explode simultaneously, but the variation in time is very little and all delays of each period explode before any of the succeeding period.

In practical work the delay electric blasting caps are used in connection with electric blasting caps. As the electric blasting caps explode immediately upon receiving the electric current, they are used in the holes that are to go first, such as cut holes, thereby relieving the burden on the second set of holes, such as relief shots, which are primed with first delays. The second set of holes is primed with second delays, the third set with third delays and so on. A better understanding of this loading may be obtained by a close study of the illustration on page 29.

Delay electric blasting caps are manufactured in Nos. 6 and 8 strengths, as are electric blasting caps. They are fitted with copper wires only and the wires have an enamel coating under the cotton insulation the same as waterproof electric blasting cap wires. The lengths of the wires are the same as for electric blasting caps, and longer wires are furnished on special order. To distinguish the several delays from one another and from electric blasting caps before and after loading, the wires on the first delays are white; those on the second delays are blue; on the third delays, red; on the fourth delays, green; and on the fifth delays, yellow. First and second delays are as a rule kept in stock but third and longer delays are made only as ordered.

Delay electric blasting caps may be connected in the same series with any of the other du Pont electric detonators or with du Pont Delay Electric Igniters. Delay electric blasting caps are packed in cartons such as are used for electric blasting caps, but the packages weigh slightly more than packages of electric blasting caps.

Delay Electric Igniters

A delay electric igniter is made up of a cylindrical copper tube, into one end of which the necessary wires and plug with the igniting material in its concave end are inserted, and into the other end of which is crimped a piece of fuse nominally 2 inches, 4 inches, 6 inches, 8 inches, 10 inches or 12 inches in length. As a matter of fact each fuse has an extra half inch of length which is to be cut off just before using the igniter to make sure of a strong end spit from the fuse. The igniters are designated as first delay, second delay, and so on to sixth delay respectively, the delay being determined by the length of the fuse. They are made with insulated copper or iron wires of the same lengths as the wires of du Pont Electric Blasting Caps. Longer wires may be had on special factory orders and also longer lengths of fuse in order to secure more delays or longer intervals of delay.

Delay electric igniters are designed for firing charges of explosives in rotation, one after another. They can be used with either blasting powder or dynamite. For use with dynamite it is necessary to cut off a half inch from the end of the fuse and crimp a No. 6 or No. 8 blasting cap to it.

By putting electric blasting caps in the cut holes or the first set of holes to be fired, first delays in the second set, second delays in the third set, and then following with as many other delays in order as required, a positive rotation of shots can be secured by one application of the electric current. Delay electric igniters with blasting caps attached are used with success in tunnel driving, shaft sinking, ore mining, or any other work of this character when it is desirable to have the shots fired in rotation. They can be used in dry or moist work, or even in wet work if the entire igniter, after the blasting cap has been crimped to it, is dipped in du Pont Cap Sealing Compound.

For use with blasting powder, it is not necessary to add a blasting cap to the delay electric igniter, but the *end* of the fuse only should be in contact with the powder.

DELAY ELECTRIC IGNITER

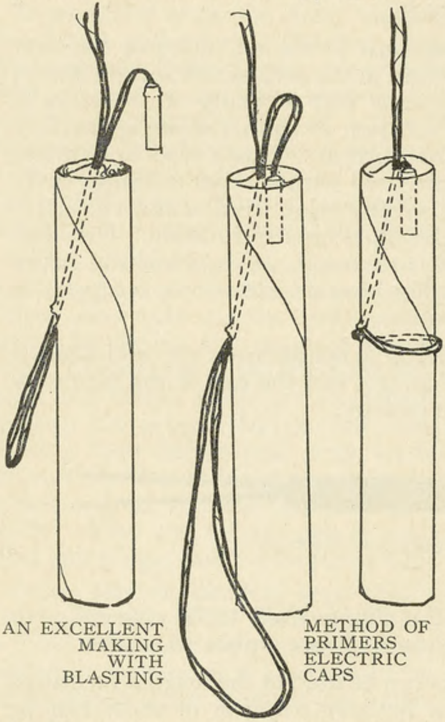
In all cases it is best for the copper shell to be covered with tamping as this allows a minimum of fuse smoke to escape.

While delay electric igniters can be used in the lengths furnished to give the desired delays, a positive rotation of shots can be obtained by cutting the fuse in lengths differing only by half an inch. Consequently, as a rule, all necessary delays can be obtained by cutting second delay igniters in such lengths as to give the number of firing periods desired. By cutting the sixth delay igniters in half-inch intervals from 18 to 20 shots can be fired in rotation. This is particularly advantageous in blasting in close proximity to timbers where it is desirable to have the shots go one at a time to avoid or reduce damage due to the concussion of several shots exploding simultaneously. This applies to sinking or raising in soft ground and in drifts or tunnels in soft ground where it is necessary to carry the timbering close to the face, also to stopes difficult of access or where there is danger of damage to the timbers from blasting.

Delay electric igniters require the same careful storage as other electric blasting accessories. They are packed in the same kind of cartons as electric blasting caps. The number packed in each carton depends on the length of the fuse.

Making Primers with Electric Detonators

Primers can be made with electric blasting caps by any of the methods described for the use of blasting cap and fuse. The waterproofing is done in exactly the same way.



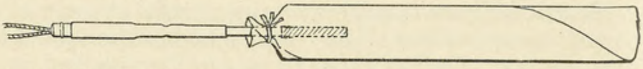
AN EXCELLENT METHOD OF MAKING PRIMERS WITH ELECTRIC BLASTING CAPS

Many blasters, however, prefer to use a slightly quicker method, which has been found entirely satisfactory. Punch a hole from the center of the end of the cartridge in a slanting direction so that it will come out at the side two or three inches from the end, insert the end of the doubled over wires of the electric blasting cap, loop these around the cartridge, and punch another hole in the top a little to one side of the first and straight down. Insert the capsule in this last hole as far as possible and take up the slack on the wires. You then have a primer in which the wires do not cross each other at any point and the capsule is lying nearly along the center line of the cartridge, a primer which hangs vertically, so that it is possible to load it in the bore hole without its lodging against the sides.

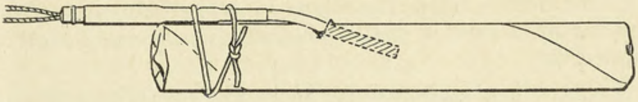
The wires of electric blasting caps should never be fastened around high explosive cartridges by half-hitching them, as a strong pull might either break the wires or cut the insulation.

Primers with other electric detonators, such as delay electric blasting caps and waterproof electric blasting caps, are made exactly as are primers with electric blasting caps, with the single difference that deeper holes in the explosive cartridge are required to receive the detonators.

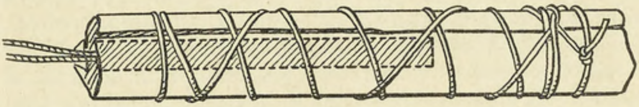
When delay electric igniters are used to detonate high explosives a blasting cap is crimped on the end of the fuse, and the priming then done as with blasting cap and safety fuse.



ONE METHOD OF MAKING A PRIMER WITH A DELAY ELECTRIC IGNITER



ANOTHER METHOD OF MAKING A PRIMER WITH A DELAY ELECTRIC IGNITER



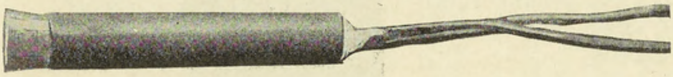
A METHOD OF MAKING A PRIMER WITH A DELAY ELECTRIC BLASTING CAP WHEN THE CARTRIDGE IS OF 1¼ INCH DIAMETER

Electric Squibs

Blasting powder is best ignited in the center of the charge. It is impossible to do this with certainty with miners' squibs or safety fuse, but it can easily be done with du Pont Electric Squibs.

When a charge of blasting powder in a long bore hole is ignited at one end, it is always possible for some of the coal or rock to move before the entire charge explodes, and thus relieve the confinement from the powder in the far end of the hole. This is most likely to happen when large charges are ignited at the end nearest the mouth of the bore hole. Then more or less of the powder at the back of the bore hole, where the burden is usually the heaviest, does very little execution, and a large flame and a great volume of smoke are projected into the working place.

Attempts to ignite the charge at the center are sometimes made by extending the fuse to that point; but this is seldom successful, owing to the fact that most fuse will spit fire from the sides and ignite the charge where the fuse enters it. Even the very best tape and gutta-percha fuse will do this occasionally.



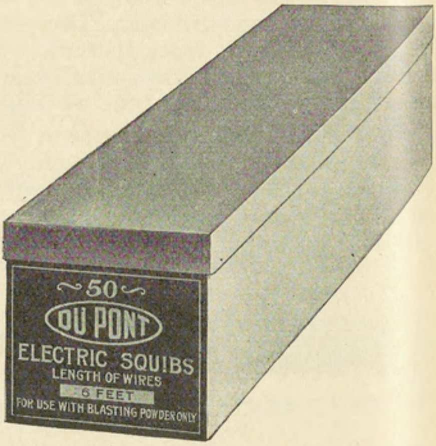
EXACT SIZE OF DU PONT ELECTRIC SQUIB

Miners' squibs, often used for igniting blasting powder charges in bore holes, are sometimes uncertain in their rate of burning, and may give but little time for the blaster to reach a place of safety after lighting them. This makes it necessary, when several shots are ready to be fired, for the blaster to return to the face a number of times, causing the loss of valuable time. The miners' squib also necessitates an opening in the tamping which may result in the flames from the blast blowing back into the open and igniting mine dust or gas. This opening makes gas-tight tamping impossible.

All of these disadvantages are overcome by the use of du Pont Electric Squibs that give all the general advantages of electrical firing. These electric squibs are similar in general appearance to du Pont Electric Blasting Caps, but have a heavy paper shell or cap instead of a copper one. The end of the shell is closed with a small cork, which should be taken out before using. The charge in this cap does not detonate as does that in an electric blasting cap, but merely shoots out a small flame. When electric squibs are used, the charge of blasting powder can be ignited in the center, thus giving a little quicker and stronger action, and insuring the explosion of the entire charge before any of the surrounding material can fall and cut off a portion of it. The bore hole can be tamped solid, leaving no vent for a partial loss of the strength of the powder. When the entire charge is exploded at once, less smoke is given off by the blast. This, with the elimination of smoke from burning safety fuse, or miners' squibs, results in purer air, making it possible for both miners, and draught animals to do more work. Aside from better blasting and greater safety, this one feature is of sufficient advantage to warrant the use of electric squibs.

Another advantage in using electric squibs is that when it is possible to fire more than one shot at a time all of the bore holes can be connected in series and fired at the same instant. This results in a very considerable saving of time, as well as powder, as shot firers can cover much more ground than when using fuse or miners' squibs.

It is much safer to blast with electric squibs than with fuse or miners' squibs, because shots are not fired until every one, including the blaster, is a safe distance away, and because danger of hang fires is entirely obviated.



CARTON OF ELECTRIC SQUIBS

Advantages resulting from the use of electric squibs are:

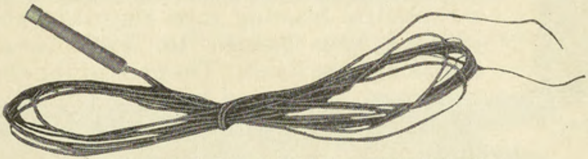
Instantaneous firing.

Control of moment of firing.

Simultaneous firing of a number of shots.
Greater efficiency of blasting powder.
Elimination of fumes from safety fuse.
Decrease of smoke from blasting powder.
Saving of time. Greater safety.

Electric squibs require the same good storage conditions as electric blasting caps. Although they cannot be exploded by shock or concussion as can electric blasting caps, they must be handled just as carefully, for their construction is necessarily delicate and they can be easily broken by rough handling.

They are manufactured with the same lengths of copper wires as du Pont Electric Blasting Caps and with 4, 5, 6 and 8-foot iron wires. Those with iron wires are somewhat less expensive, but require a stronger electric current to explode them, because of the inferior conductivity of iron as compared with copper wire. They are also more easily affected by moisture. We do not recommend electric squibs with iron wires longer than 8 feet, nor do we carry them in stock.



ELECTRIC SQUIB WITH 6-FOOT WIRES

Electric squibs are packed 50 to the carton and 10 cartons to the case. Gross and net weights and dimensions of cases are as follows:

Quantity per Case	Length Feet	Wire	Gross Lbs.	Net Lbs.	CASE (Outside Dimen.) Length Width Depth
500	4	Iron	25	16½	22" x 11½" x 9½"
500	5	"	27	18½	22" x 11½" x 9½"
500	6	"	32	23½	22" x 11½" x 9½"
500	8	"	39	29	22" x 15½" x 9½"
500	4	Copper	23	15½	22" x 9½" x 9½"
500	6	"	29	21½	22" x 9½" x 9½"
500	8	"	36	27½	22" x 11½" x 9½"
500	10	"	42	33½	22" x 11½" x 9½"
500	12	"	51	41	22" x 15½" x 9½"
500	14	"	57	47	22" x 15½" x 9½"
500	16	"	64	53¼	22" x 17½" x 9½"
250	18	"	43	32¼	22" x 17½" x 9½"
250	20	"	46	35¼	22" x 17½" x 9½"
250	22	"	49	38¼	22" x 17½" x 9½"
250	24	"	52	41¼	22" x 17½" x 9½"
250	26	"	55	44¼	22" x 17½" x 9½"
250	28	"	58	47¼	22" x 17½" x 9½"
250	30	"	61	50¼	22" x 17½" x 9½"

Cases of ½-inch material.
For inside dimensions deduct 1 inch from length, width and depth.

Photographic Squibs

The use of electric squibs is highly successful for firing photographic flash powders. By their use any number of flashes may be fired at the same time. The action is positive. For this work the squibs may be fired by means of a blasting machine or an electric lighting circuit. Photographic electric squibs are made with 6-inch copper wires. They are connected in exactly the same manner as du Pont Electric Squibs and Electric Blasting Caps.

Connecting Wire

Connecting wire is insulated copper wire (No. 20 Brown & Sharpe gauge). It is put up in 1-pound and 2-pound spools. A 1-pound spool is 3 inches in diameter, 4 inches long and holds about 210 feet of wire. A 2-pound spool is 3 inches in diameter, 5½ inches long and holds about 420 feet of wire.

Connecting Wire
(1-lb. Spool)

Connecting wire is used to join the wires of the electric blasting caps together, when they are not long enough to reach between the adjoining bore holes. The ends of the connecting wire must be scraped bright before connections are made. The joints should not be permitted to lie in water or on wet ground. If this cannot be prevented, the joint should be covered with insulating tape.

No. 21 (Brown & Sharpe gauge) Insulated Copper Wire is also used for connecting wire, but is not recommended because it is considered too small for best results.

A 1-pound spool of No. 21 Connecting Wire holds about 260 feet and a 2-pound spool about 520 feet.

The resistance of No. 20 Insulated Copper Connecting Wire is 10.14 ohms per thousand feet. The resistance of the No. 21 size is 12.78 ohms per thousand feet.

Leading Wire

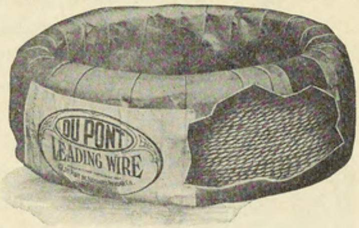
The wire commonly used for connecting electric blasting caps, other electric detonators, and electric squibs to the blasting machine is known as leading wire. It is insulated copper wire (No. 14 Brown & Sharpe gauge) and is furnished in coils of the following lengths and weights:

200 ft.	about 4 lbs.	300 ft.	about 5.8 lbs.
250 ft.	about 5 lbs.	500 ft.	about 9.6 lbs.

The leading wire should always be long enough to keep the blaster well out of the zone of danger.

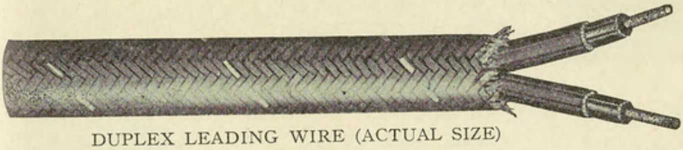
Duplex leading wire is made by binding together two insulated copper wires with an outside insulation, thus giving a return circuit cable that may be handled the same as a single wire. It weighs approximately twice as much as the same length of single leading wire and can be had in coils of the same lengths.

Duplex wire is more satisfactory for use where the two end holes in a blast are not far apart, as in stump blasting and similar work. Single wire is generally preferred to the duplex where the end holes are far apart, as in quarry and electric ditch blasting. Single leading wire is frequently used for connecting wire instead of the small gauge connecting wire, especially in large blasts.



ROLL OF LEADING WIRE

SINGLE LEADING WIRE SLIGHTLY REDUCED



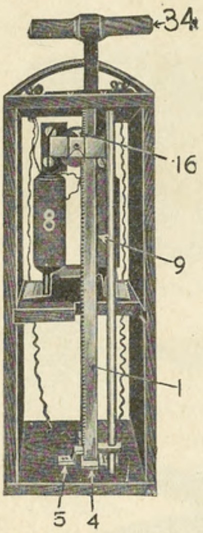
DUPLEX LEADING WIRE (ACTUAL SIZE)

For use in coal mines and a few other places where but from one to three charges are fired in a blast, and then under conditions where it is not necessary to be far from the blast, a special 18-gauge rubber covered duplex leading wire is furnished in 100 and 150 foot lengths. This wire weighs 2.39 pounds per hundred feet. This leading wire is intended only for the work specified and not for general blasting.

Blasting Machines

Blasting machines are used to generate the current for firing blasts by electricity.

Du Pont Blasting Machines, with the exception of the Pocket Blasting Machine, are small portable dynamos, in which the armature is rotated by the downward thrust of the rack bar, thereby converting muscular energy into electrical energy. They are not magnetos, although they are often erroneously so called. A magneto has a permanent magnet for a field, whereas the dynamos in the du Pont Blasting Machines have electro-magnets. They are wound somewhat differently from a dynamo built for delivering a continuous current for power or lighting purposes, in that the current in the du Pont Blasting Machines is short circuited through the field magnets for the purpose of building up, intensifying and storing the current until the end of the rack bar stroke, when the whole accumulated current is sent out through the firing line.



PARTS OF DU PONT BLASTING MACHINE

The construction of the push-down du Pont Blasting Machines is shown in the accompanying illustration. 1, Rack bar, showing teeth which engage the pinion on end of armature; 4, the contact spring, which, when struck by the bottom of the descending rack bar, breaks the contact between two small platinum bearings, one on the upper face of the contact spring and the other on the under side of the bridge 5, and in this way throws the entire current through the outside circuit; that is, leading wire, electric blasting caps and connecting wire; 8, 9, field magnets; 16, revolving armature; 34, rack bar handle.

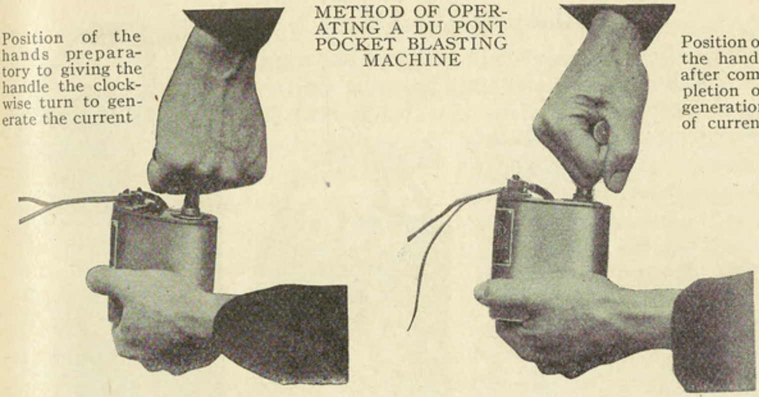
Blasting machines are rated according to the number of electric blasting caps that they can be depended upon to fire when connected in series. For convenience, the electric blasting cap with 30-foot copper wires is taken as the unit.

Du Pont Pocket Blasting Machine

Pocket Size

The Pocket Blasting Machine is a light-weight machine, having permanent field magnets. It has a capacity of three electric blasting caps. This machine is serviceable for stump and boulder blasting and for other small jobs which call for firing one, two or three holes at a time. It weighs 4½ pounds. It is furnished with a removable handle, which prevents its being operated by any other person than the blaster.

To operate the du Pont Pocket Blasting Machine, first remove the carrying handle from the socket and insert the firing handle, taking care to see that it is properly engaged in the teeth below. Hold the machine firmly in one hand, with the other hand on the handle. When ready to fire, give the handle a quick, hard turn in a clockwise direction. This generates the current and causes it to flow through the leading wires.



METHOD OF OPERATING A DU PONT POCKET BLASTING MACHINE

Position of the hands preparatory to giving the handle the clockwise turn to generate the current

Position of the hands after completion of generation of current

Du Pont Permissible Pocket Blasting Machine

PERMISSIBLE
SINGLE-SHOT BLASTING UNIT
No.1202
CAUTION

DU PONT PERMISSIBLE POCKET BLASTING MACHINE

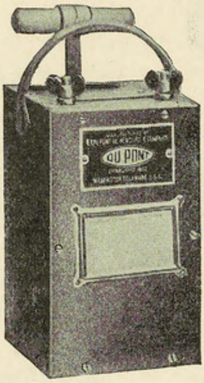
The Permissible Pocket Blasting Machine has been passed by the United States Bureau of Mines as a single shot blasting unit permissible for firing charges of explosive in gaseous and dusty coal mines. It is similar in construction to the du Pont Pocket Blasting Machine but the capacity is less and inside the case there is an insulation of hard rubber which eliminates the possibility of premature firing of an electric blasting cap by contact between the ends of the wires and the metal case. It has both a carrying handle and a firing handle and is operated in the same manner as the Pocket Machine previously described.

No. 2 Blasting Machine

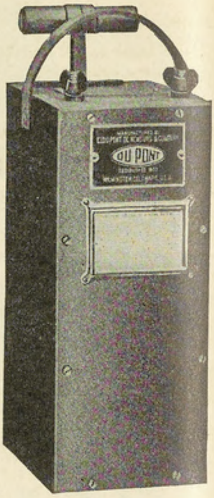
The No. 2 size is generally used in stump and boulder blasting, for springing bore holes on large work, and for mining where it is desired to fire more than three electric blasting caps at a time. It is strongly made, weighs 15 pounds, and has a capacity of ten electric blasting caps with copper wires, or seven electric blasting caps with iron wires.

No. 3 Blasting Machine

This is a machine for quarry and mine. It has a capacity of thirty electric blasting caps with copper wires and weighs 25 lbs. Due to its small size this blasting machine can be easily carried and operated with satisfactory results. It is suitable for all general blasting operations, where a larger blasting machine is not necessary, and even where a smaller one, except the pocket blasting machine, will do the work. It is small enough to be carried easily, and yet is strong enough for anything except the largest blasts.



No. 2



No. 3

No. 3-A Blasting Machine

The No. 3-A Machine is a machine of recent design which has a capacity of fifty electric blasting caps with copper wires, yet weighs only 23 pounds. It is recommended for all general blasting operations.

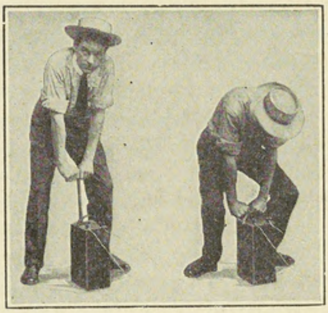
All du Pont Blasting Machines are securely boxed for shipment. The shipping boxes make excellent containers for storing and protecting blasting machines when they are not in use.

Capacities and Uses of du Pont Blasting Machines

Size of Machine	Capacity, Number of 30-foot Electric Blasting Caps, Copper Wires	Used For
Pocket	1 to 3	Mining, stumping and boulder blasting.
Permissible Pocket	1	Coal mining.
No. 2	1 to 10	Springing bore holes, all classes of small blasts.
No. 3	1 to 30	General work, mining and quarrying.
No. 3-A	1 to 50	Mining, quarrying and contracting.

Operating a du Pont Push-Down Blasting Machine

To operate the push-down blasting machine (Nos. 2, 3 and 3-A), set it squarely on a solid, level place, connect the leading wires as described on page 60, lift up the rack bar by the handle to its full extent, and with one quick, hard stroke push it down to the bottom of the box with a *solid thud* using both hands. Try to knock the bottom out of the machine. As the rack bar approaches the bottom, it becomes more difficult to operate, because of the building up of the current; but the speed of the thrust should not be diminished, because the finish of the operation is more important than the start. Do not be afraid of pushing the rack bar down too hard. The machine is built to stand it, and this is the only way to use it successfully.


OPERATING A DU PONT BLASTING MACHINE

Care of Blasting Machines

Du Pont Blasting Machines are strongly made, and will stand with little deterioration the treatment to which it is necessary to subject them. Their mechanism, though designed as simply as possible, is more or less complicated and delicate, and they must be treated with at least some consideration. There can be no possible excuse for throwing a blasting machine about, or permitting it to remain exposed to wet weather or lying in the mud. If a blasting machine is treated in this way, its life will be short and its usefulness limited.

When you use the blasting machine, try to find a clean, level place to stand it on, such as a dry plank, so that the bottom will not be wet when you put it away after using.

The efficiency of the blasting machine may be kept up to the maximum by occasional inspection and care of the internal parts, although they are so constructed as seldom to require much care.

The first thing to be considered in caring for the dynamo and working parts is occasional oiling. Good judgment should be used here, for too much oil is worse than none at all. The only parts that need oil are the bearings of the armature shaft and of the armature pinion. The other iron parts that can be reached, particularly the faces of the armature (not the wire), should be wiped off with a greasy rag to prevent them from rusting. *No oil should be used on, or allowed to come in contact with, the brushes, commutator, or with the contact spring and its contact points.* For this reason, the amount of oil used in any part of the blasting machine should be small; if too much is used the oil will afterwards flow over into places where it is not wanted. This is especially the case when the rack bar is oiled. Too much oil here will inevitably flow down upon the contact spring and its contact points, and cause a poor electrical connection with the bridge. In fact, a poor electrical connection at this point is one of the most common causes of poor work and erratic behavior on the part of a blasting machine. Wiping off the rack bar and guide rod with a greasy rag will give them all the lubrication they require.

The friction incident to ordinary usage will generally be sufficient to keep the surfaces bright where the brushes bear upon the commutator, *unless* some misguided person has oiled them. In that case, the oil should be removed as well as possible by thorough cleaning with a rag saturated with gasoline. If the brushes seem to be too rapidly wearing into the commutator, so that they absolutely demand some kind of lubricant, use a little graphite taken from a soft lead pencil. After removing the oil by the use of gasoline, be sure that all the gasoline and its vapor are out of the box before closing it up; if confined, the vapor may afterwards ignite and blow the box apart.

If the commutator becomes badly discolored or dirty and needs cleaning, hold a piece of fine sandpaper, No. 00, against it while rotating it slowly. Never use emery. See that the two slots cut in the copper part of the commutator are clean, and with no particle of metal or anything else in them which might cause a short circuit. Keep the copper brushes (see 16, page 38) clean, and see that they bear firmly on the commutator.

All contact points on the contact spring, bridge, and elsewhere may be cleaned occasionally with fine sandpaper. However, sandpaper should be used in or about a blasting machine only with the greatest care. Dust or fine particles from the sandpaper must not be allowed to get into the working parts of the machine, as they will cause these parts to wear out rapidly. Care must also be taken, especially when cleaning the platinum contact points, not to rub too vigorously. A gentle rubbing is sufficient to remove any dirt or oxide and brighten the parts, whereas a few vigorous rubbings will grind off the platinum points themselves. If the platinum is ground away so that only brass remains, the working of the machine will be impaired, for the brass quickly becomes oxidized by the hot flash given off when the circuit is broken, and thereafter fails to make a good contact.

When a blasting machine is not in use, store it in a dry and comparatively cool place—not in a leaky tool box or on top of a boiler. Neither is a wet tunnel or mine a good place to store a blasting machine, and if it must be used in such places, as is often the case, and it cannot be taken to the surface between times, as is sometimes the case, a water-tight closet or box should be built for it, in as good a location as can be found. Remember that the case is only wood, and, if saturated with water, may swell and put the internal parts out of adjustment. Occasionally rubbing a *little* oil—preferably thick cylinder oil—into the grain of the wood will help it to resist the water. The best way to apply the oil is by rubbing the box with a greasy rag.

Every blasting machine is tested thoroughly before leaving the works. If a new one does not give satisfactory results when received, it may not have been operated properly or may have been injured by rough handling during transportation.

Every blasting machine should be tested occasionally with a du Pont Rheostat.

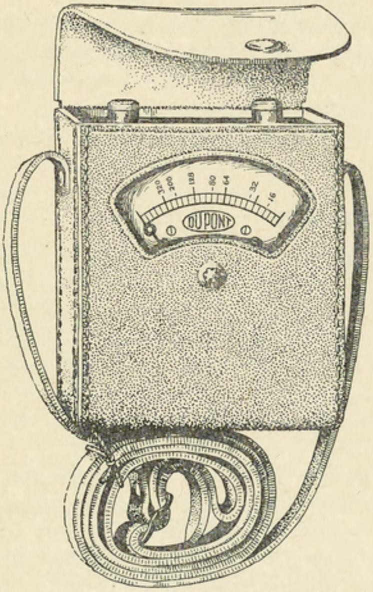
Galvanometer

The galvanometer is a small instrument used to determine whether a blasting circuit is closed or open; that is, whether the circuit is in the proper condition for the blast, or, because of defective wires or poor connections, will fail to transmit the electric current. The du Pont Galvanometer can be used also to measure the amount of resistance, thus indicating the existence of leaks or short circuits. It is of value in testing not only blasting circuits, but also individual electric detonators.

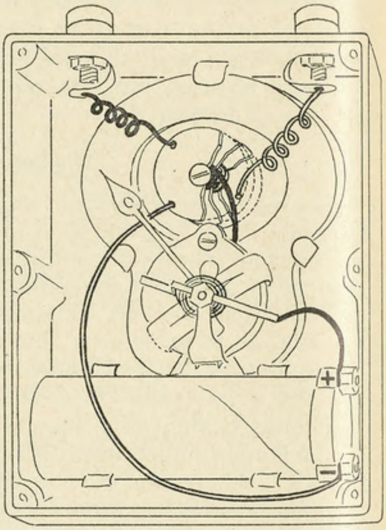
The instrument is a magnetic device in which an electric current from a small chloride of silver dry cell moves a pointer across a scale. There are two binding posts conveniently located for connections. When a passageway (circuit) is offered, so that the electric current can pass from one binding post to the other, the current from the battery cell flows through this circuit, traversing the galvanometer coil on the way, causing the pointer to be deflected. The cell and needle are contained in a case made of metal and hard rubber, which is in turn contained in a leather carrying case. The galvanometer is small and flat and may be carried comfortably in the pocket, or, when in use, slung from the shoulder by the strap.

The battery cell is one selected after a long series of experiments. While of long life and of great constancy, it is very weak. The current which is sent through an electric detonator when making a test with the assembled instrument is less than one-tenth of the strength required to explode it. The length of time a battery cell will last depends, of course, upon how frequently it is used and how long the current is allowed to flow in making each test. When properly used, one cell is sufficient for several thousand tests. The simple form of connection enables the user easily to replace the exhausted cell with a new one. The cell is very small and light and can be sent by mail.

As the construction of the galvanometer and the methods for using it are quite simple, the instrument is adapted to the requirements of the practical blaster as distinguished from the trained electrician, whose finer instruments and methods would be at a disadvantage under the conditions prevailing on the ordinary electric blasting job. The galvanometer gives as accurate electrical tests as are ordinarily needed in blasting work.



GALVANOMETER ENCLOSED IN
LEATHER CARRIER



INTERIOR OF GALVANOMETER
SHOWING WIRING CIRCUITS

Principle of Construction of du Pont Galvanometer

▬▬▬The solid black line shows the path of the current from the positive pole of the silver chloride dry cell, through the coil which actuates the needle, through the winding of the spool within the electro-magnet, and through a coil to one post of the galvanometer.

═══The double line shows the path of the current through the negative pole of the dry cell, also through the winding of the spool, and through a coil to the other post of the galvanometer.

We recommend the du Pont Galvanometer to our customers because it is a convenience and a time-saver and because the exactness of operation which it makes possible secures better execution from explosives, lessens the risk of blast failures, and minimizes the danger of accidents.

Care of Galvanometer

Although the galvanometer is simple in design, and as substantially made as possible for such an instrument, some of the parts are necessarily of delicate construction. It should, therefore, be handled carefully and kept perfectly dry.

The galvanometer should be tested before being used by placing a short piece of copper wire momentarily across its two binding posts. The wire having almost no resistance, the needle should be deflected to its widest limit. If it does not move or does not move clear across the scale, the battery cell is wholly or partially exhausted. Before using a galvanometer with a partially exhausted cell to measure the amount of resistance of a blasting circuit, the galvanometer should be tested with a rheostat and its scale recalibrated.

To renew the battery cell, carefully take out the screws in the face of the metal case, using a good screwdriver of the right size. The exhausted cell is then easily lifted out, and the connecting wires are transferred to the fresh cell. The only precaution necessary is to be sure the + and — poles are connected to the corresponding wires. The connectors at the ends of the cell wires are marked + and —, and so no difficulty should be experienced.

Every du Pont Galvanometer bears the following warning and strict heed should be paid to it. "Do not replace the silver chloride cell in this instrument with any other type of cell and do not connect cell so that the galvanometer coil is cut out of the circuit. A different kind of cell or a connection in which the resistance of the galvanometer coil is cut out of the circuit may result in a current being sent through the electric blasting cap in testing sufficiently strong to fire it."

Method of Operating

Testing a Circuit.—To test a circuit to ascertain whether it is closed or open it is necessary only to touch the ends of the two leading wires to the two binding posts of the galvanometer, after all connections are ready for the blast. If the circuit is closed, the needle will move along the scale. If the needle does not move there is a break in the circuit. To make a more accurate test of the condition of a blasting circuit, it is necessary first to calculate the resistance of the entire circuit from the figures given in the resistance tables on page 47 and to compare the resistance shown by the galvanometer test with this calculated resistance.

To calculate the resistance of any blasting circuit connected in series, multiply the resistance of one firing device by the number in the circuit. Add to this the resistance of the leading wire and the connecting wire, and the result will be the total resistance of the circuit.

For example, if in a given blast 50 electric blasting caps with copper wires 20 feet long are used, also 100 feet of No. 20 connecting wire and 500 feet of No. 14 single leading wire (or

250 feet of duplex wire), the total resistance would be found in the following manner:

One electric blasting cap with 20 ft. copper wire has resistance of 1.857 ohms. 50 such caps have resistance of	92.85 ohms
1000 feet of No. 20 connecting wire has resistance of 10.14 ohms. 100 feet has resistance of	1.014 "
1000 feet of No. 14 leading wire has resistance of 2.521 ohms. 500 feet has resistance of	1.26 "
The total resistance of the entire circuit would be	95.12 ohms.

When exceptionally long lengths of leading or connecting wire are used in blasting circuits, the resistance should be computed and added to that of the electric detonators to guard against overloading the blasting machine.

If the galvanometer reading is lower than the calculated resistance, there is a short circuit or ground through which some of the current is leaking away. If it is appreciably higher than the calculated resistance, there is a place of high resistance, probably in a poorly made connection.

The galvanometer can be used for testing circuits only when the electric detonators are connected in series. (See pages 53-55.) In a parallel circuit, each electric detonator must be tested separately. A parallel series circuit must be separated into individual series and each series tested by itself.

Locating a Break.—To locate a break make sure that the ends of the leading wires to be attached are separated and not touching anything (see page 48). Secure a piece of connecting wire, N, to one end connection, D, of the circuit. This wire must be long enough to reach from the joint D to joint C. Now touch the free end of the wire N to the contact post L of the galvanometer, and either direct or through the second piece of leading wire M, touch the other contact post of the galvanometer to the joint C. If the galvanometer now shows circuit while it did not when the test was made from the other end of the leading wires, the break is in the leading wires and they must be repaired. If it does not show circuit, find the break in the electric blasting cap or connecting wire by holding the end of wire N to contact post L and touching the other contact post (or the short piece of wire M touching the contact post on the galvanometer) to each of the bare joints E, F, G and H in succession. As long as you are "inside" the break, these contacts will cause the needle to be deflected. As soon as you get beyond the break or point of high resistance, you get either a very slight deflection or none at all. In this way the trouble can be quickly traced to the break or bad joint. For instance, if a wire in bore hole No. 3 is broken, you get a deflection when M is touched to F, but none on touching G; this shows that the break is between F and G. The break can then be easily repaired if above the tamping.

If below the tamping and there are two electric detonators in the hole, the broken one can be left out of the wiring and the hole fired by the good one.

If there is but one electric blasting cap in the hole and its wires are broken off below the tamping, the hole must be handled as a misfired shot.

Table of Resistance in Ohms of Electrical Firing Devices

Length of Wires of Electric Firing Devices in Feet	Regular Copper Wire Electric Blasting Caps and Duplex Copper Wire Electric Blasting Caps	Waterproof Electric Blasting Caps with Enameled Copper Wires	"Panama" Electric Blasting Caps Copper Wire Only	Delay Electric Blasting Caps, Delay Electric Igniters and Electric Squibs with Copper Wires	Electric Blasting Caps with Iron Wires	Electric Squibs and Delay Electric Igniters with Iron Wires
4	1.255	1.255		0.935	2.093	1.857
5					2.261	2.000
6	1.343	1.343		1.000	2.448	2.261
8	1.439	1.439		1.068	3.000	2.529
10	1.500	1.500		1.143	3.280	3.000
12	1.608	1.608		1.206	3.690	
14	1.679	1.679		1.272		
16	1.727	1.727		1.325		
18	1.803	1.803		1.400		
20	1.857	1.479	1.479	1.459		
22	1.913	1.521	1.521	1.521		
24	1.970	1.564	1.564	1.586		
26	2.030	1.631	1.631	1.655		
28	2.093	1.679	1.679	1.727		
30	2.158	1.727	1.727	1.777		

Note that Waterproof Electric Blasting Cap Wires up to lengths of 20 ft. are No. 22 gauge; in lengths of 20 ft. and over, No. 20 gauge.

Each foot of electric blasting cap wire doubled (2 wires) has a resistance of .032 ohms.

The bridge of each electric blasting cap has a resistance of 1.10 ohms.

The bridge of the electric squib, delay electric blasting cap or delay electric igniter has a resistance of .859 ohms.

The resistance of the iron wire of the size used for du Pont iron wire electric firing devices is about 101.0 ohms per 1000 feet.

Table of Resistance of Copper Leading and Connecting Wire in Ohms per 1000 Feet

No. 8 Brown & Sharpe Gauge	.6271 Ohms	Usual size for power and lighting circuits.
No. 10 " " " "	.9972 "	
No. 12 " " " "	1.586 "	
No. 14 " " " "	2.521 "	Standard gauge for leading wire.
No. 16 " " " "	4.009 "	Sometimes used for short leading wire.
No. 18 " " " "	6.374 "	
No. 20 " " " "	10.14 "	Connecting wire.
No. 21 " " " "	12.78 "	
No. 22 " " " "	16.12 "	Standard size for copper wire electric firing devices.

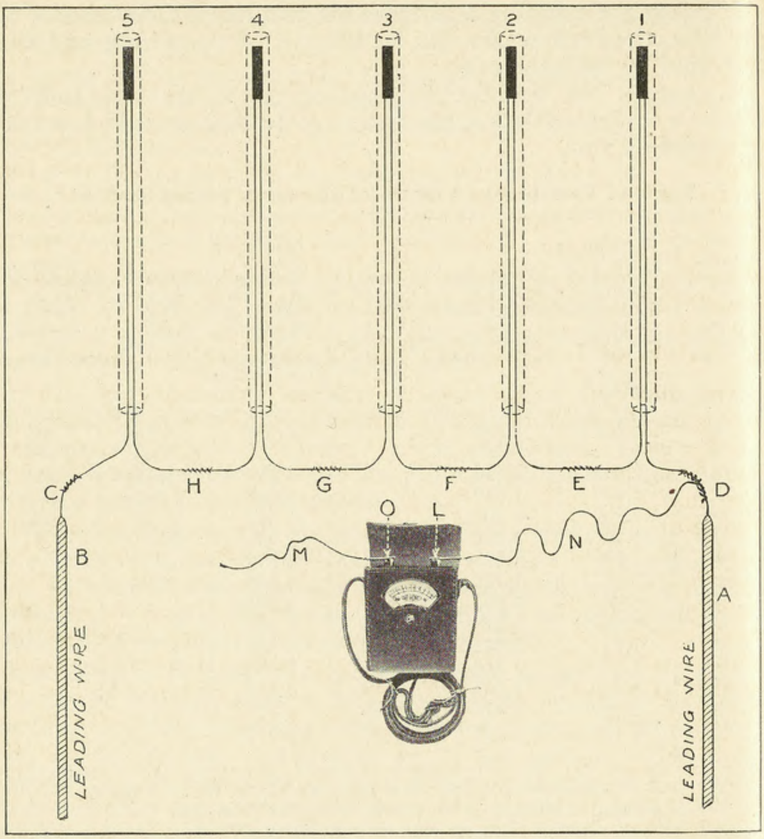


DIAGRAM SHOWING METHOD OF LOCATING A BREAK WITH A DU PONT GALVANOMETER

Testing Single Electric Detonators.—If electric detonators could always be used just as they come from the factory, without being subjected to the unfavorable conditions they so often meet with in transportation and storage, it is probable that there would be little need for testing because every manufacturer carefully tests his goods before sending them out. The du Pont Company tests its detonators twice. However, since electric detonators are liable to damage during transportation and storage, and particularly so if they are stored in a damp place, it is an excellent practice to test each electric detonator with the du Pont Galvanometer both before priming and after finishing the loading, but before tamping the hole, and also while tamping if the tamping is several feet deep. The test can be made simply by touching the ends of the electric detonator wires to the two contact posts of the galvanometer. This will reveal the most common defect, the presence of a broken bridge. A galvanometer, however, will not indicate electric detonators which are defective through a short circuit, such as those in which the wires are not insulated from each other within the detonator, or have accidentally come in contact after having been manufactured. In such cases the electric detonators would fail to fire, of course, because the current would follow the short circuit and not go through the bridge. To identify electric detonators defective from this cause it is necessary to have some instrument which will measure electrical resistance more accurately than a galvanometer.

Safety of Testing with the du Pont Galvanometer

The question is often asked whether it is absolutely safe to pass even the weak testing current of this galvanometer through a single electric detonator. To this we are obliged to reply that there is nothing in the handling of explosives or electric blasting caps that can be said to be entirely safe. However, the current from a du Pont Galvanometer has never been known to explode an electric blasting cap, and we have tested many millions. The fact that both the positive and the negative wires of the galvanometer, as shown in the illustration on page 44, pass through the resistance of the spool, would seem to assure the safety of the instrument for even if the current from one of these wires should be short-circuited through the metal case, there would still be sufficient resistance in the other path in proportion to the weak current generated by the particular type of cell used to safeguard against premature explosion of a blasting circuit in the galvanometer test. (See instructions in regard to replacing the cell on page 45.)

There are, however, grave chances of firing an electric blasting cap by testing with an ordinary series magneto telephone bell or other unsuitable instrument. Several persons have been badly injured in this way because they not only made use of an improper testing instrument, but also neglected to place the electric blasting cap in a safe location. It is remarkable what extensive damage the flying particles of copper from one of these electric blasting caps are capable of doing.

The current from a magneto bell is too weak to fire an electric blasting cap by heating its bridge, but it is of sufficient intensity to jump across a small gap, such as would result if an electric blasting cap had a broken bridge, and the broken ends were very close to each other. When the current jumps across such a gap, a spark is produced which is often sufficient to ignite the explosive mixture. Another way in which an electric blasting cap might become sensitive to the current from a magneto bell is by the formation of corrosion between the ends of a break, as in case, through the entrance of moisture, the copper wire should corrode off the bridge at one of the soldered joints. Should the electric blasting cap subsequently dry out, it may show a resistance several hundred times greater than normal, and would be very likely to fire from the current from a magneto bell, while there would be very little likelihood of its firing from the weak current from a suitable testing battery like that in the du Pont Galvanometer.

What lulls the suspicion of a blaster who tests with a magneto (and the matter is mentioned here because there are many who do) is the fact that he is often able to test a great many electric blasting caps with it before one of them explodes in the testing process. But some day one that is defective in the manner above described is encountered—and then, too frequently, it means a maimed hand, blindness or worse. For this reason, the use of any kind of testing current, except that from a weak battery used in connection with a galvanometer, or Wheatstone bridge, is most earnestly condemned.

Those who question the safety of testing with a galvanometer in the manner outlined above can insure greater safety, when testing a single electric blasting cap, by placing it in a short piece of iron pipe, or similar receptacle, so that its accidental detonation would do no harm. In locating breaks in a circuit where the electric detonators are in the bore holes, the tests can be made from a safe distance, through a pair of leading wires. The latter procedure involves, of course, a trip to the loaded bore hole every time the connections are changed for a new test.

Rheostat

The du Pont Rheostat is a simple little instrument used for testing the efficiency of blasting machines in an economical and positive manner.

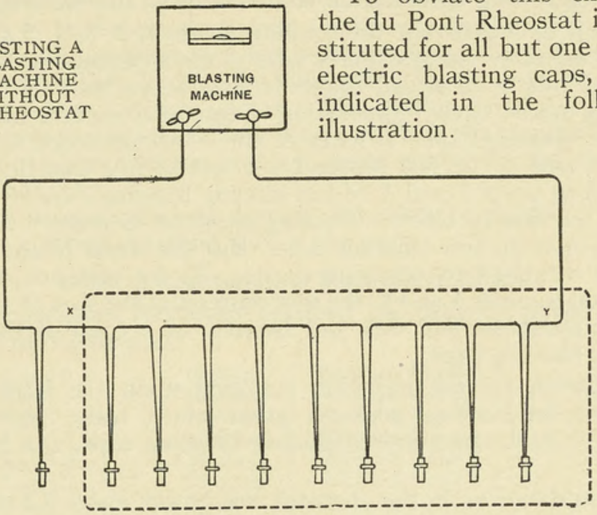
5
10
20
25
40
DU PONT RHEOSTAT
FOR TESTING
BLASTING MACHINES

Dimensions, ¾" x 1¾" x 4 13/16"
Weight, 5 oz.

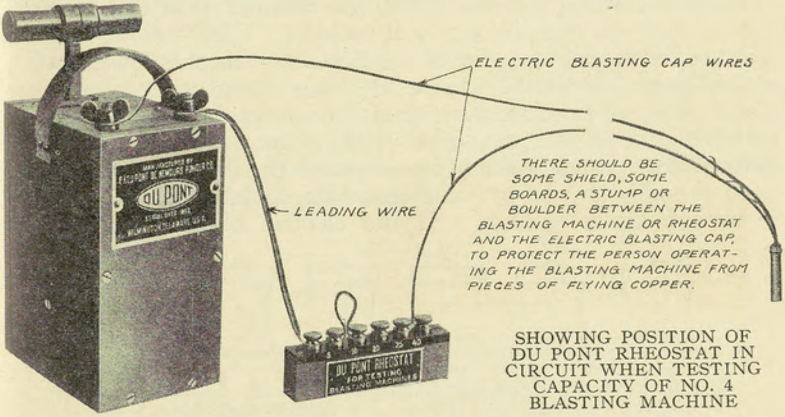
One way to test, for example, a No. 2 blasting machine, which has a capacity of ten electric blasting caps is to connect ten electric blasting caps in series and then to the blasting machine and operate the machine. If all the electric blasting caps fired, the machine would be working up to its rated capacity; if the electric blasting caps did not fire, the machine would not be up to standard. The results obtained would be absolutely accurate. The objection to this method is that it consumes so many electric blasting caps, thus causing needless expense. If a No. 5 or 6 blasting machine were being tested, one hundred or one hundred and fifty electric blasting caps would be required for the test. Moreover, the firing of so many electric blasting caps in the open would be dangerous.

To obviate this expense, the du Pont Rheostat is substituted for all but one of the electric blasting caps, as is indicated in the following illustration.

TESTING A BLASTING MACHINE WITHOUT A RHEOSTAT



When such a series connection is made and the blasting machine operated, the single electric blasting cap either fires or does not fire, and indicates whether or not the blasting machine is up to capacity.


ELECTRIC BLASTING CAP WIRES
LEADING WIRE
DU PONT
DU PONT RHEOSTAT FOR TESTING BLASTING MACHINES

THERE SHOULD BE SOME SHIELD, SOME BOARDS, A STUMP OR BOULDER BETWEEN THE BLASTING MACHINE OR RHEOSTAT AND THE ELECTRIC BLASTING CAP, TO PROTECT THE PERSON OPERATING THE BLASTING MACHINE FROM PIECES OF FLYING COPPER.

SHOWING POSITION OF DU PONT RHEOSTAT IN CIRCUIT WHEN TESTING CAPACITY OF NO. 4 BLASTING MACHINE

The internal construction of the rheostat is shown diagrammatically on page 52. It is an arrangement of coils of high resistance wire of a certain length, with the binding posts 1 and 6 attached to its ends, and the binding posts 2, 3, 4 and 5 attached to it at intermediate points. The entire length of the resistance wire in the rheostat has a resistance sufficient to represent a test of one hundred 30-foot electric blasting caps, with the leading wire, connecting wire and all connections in the blasting circuit.

It will be noted that the binding posts, 1, 2, 3, 4, 5 and 6 are not attached to the resistance wire at equal distances. The purpose of this is to afford different resistances between different binding posts, each representing a test of a certain number of electric blasting caps. If wires X and Y are attached to binding posts 1 and 2, the test represents a test of five electric blasting caps; if to posts 2 and 3, of ten electric blasting caps; to posts 3 and 4, of twenty electric blasting caps; or to posts 4 and 5, of twenty-five electric blasting caps. But the wires X and Y need not be attached to adjoining posts. If, for instance, they are attached to posts 1 and 4, the test represents the sum of the intervening numbers, five, ten and twenty, or a total of thirty-five electric blasting caps.

As shown by the numbers stamped upon the hard rubber between the binding posts, a great many tests, representing from five up to one hundred electric blasting caps, can be easily made.

The resistances in the rheostat are based upon 3.2 ohms per unit of resistance, this being the resistance of a 12-foot copper wire electric blasting cap with a factor of safety of 2. If the electric blasting caps in use are of shorter lengths, it will be possible to fire a greater number than this test will indicate, even, in some cases, up to twice the number. On the other hand, there may be circumstances which will cut down the number that can be fired below what the rheostat test will indicate. Chief among these is leakage of electric current in some part of the blasting circuit, either from bare joints or wire touching damp ground, or other conductors, or from fluids of great penetrating qualities coming in contact with the insulation of the wires for too long a time before firing. Of these fluids, the worst are the strong saline liquids, even though they be in small amounts, and bore-hole washings in certain kinds of rock. If the electric blasting caps differ

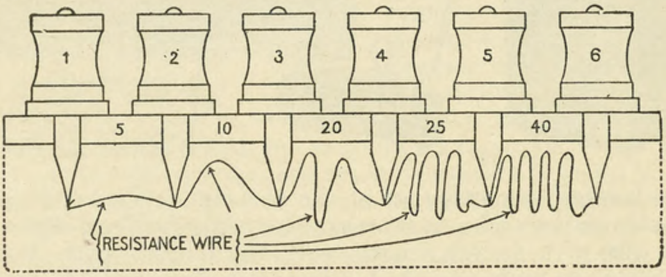


DIAGRAM OF CONSTRUCTION OF A RHEOSTAT

greatly in sensitiveness to the firing current, this will also cut down the number that can be depended upon to fire simultaneously.

When testing blasting machines having capacities of more than one hundred detonators, two rheostats are used in series.

Should it be necessary to test a blasting machine for ninety detonators, the resistance of ten, between posts 2 and 3, must be blocked out. This is done by connecting these posts by means of a piece of heavy copper wire or a coin. In this way the resistance between any two posts can be subtracted from the total resistance or the resistance between any two posts outside of the two that are blocked out.

Be sure to use only one electric detonator or electric squib in testing a blasting machine with a rheostat.

Table of Resistances of Rheostat in Ohms

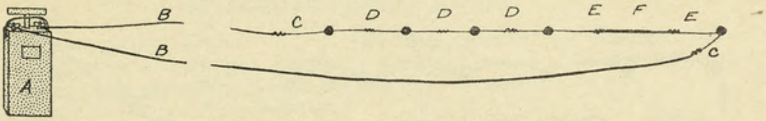
The resistances furnished between the different posts of the rheostat are as follows:

Between 1 and 2	16 ohms	Between 1 and 5	192 ohms
Between 2 and 3	32 ohms	Between 1 and 6	320 ohms
Between 3 and 4	64 ohms	Between 2 and 4	96 ohms
Between 4 and 5	80 ohms	Between 2 and 5	176 ohms
Between 5 and 6	128 ohms	Between 2 and 6	304 ohms
Between 1 and 3	48 ohms	Between 3 and 5	144 ohms
Between 1 and 4	112 ohms	Between 3 and 6	272 ohms
Between 4 and 6	208 ohms		

Wiring for Electric Blasts

When firing by electricity, whether using any of the electric detonators, or electric squibs or delay electric igniters, the holes may be connected in one of three ways,—in series, in parallel, or in parallel series.

Series Connections.—When using a blasting machine the detonators must be connected in series. The series connection is made by connecting one wire from each hole to one wire in the next hole and so on until only the two end wires are left free. These are connected to the ends of the leading wire. All of this is shown in the following illustration:

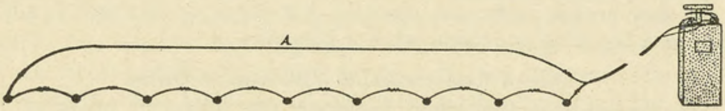


SERIES CONNECTION FOR ELECTRICAL FIRING

A. Blasting machine. B. The two strands of single leading wire.
C. Connections between leading wire and electric blasting cap wires.
D. Connections between electric blasting cap wires.
E. Connections between electric blasting cap wires and a short piece of connecting wire F, used to connect electric blasting cap wires that are too short to reach from hole to hole. This may be left out when long electric blasting cap wires are used, or it may be used between all holes in some cases.

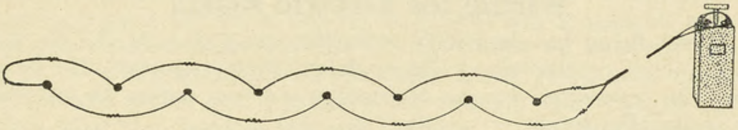
This method of wiring can also be used when a power or lighting circuit is used for firing the blast. A power current of 1½ amperes is required for each series and a sufficient voltage to overcome the resistance of the circuit, as is shown by the resistance tables on page 47.

When duplex wire is used a piece of connecting wire, A, is required to connect the extreme end to the leading wire as is shown. This has a single objection in that it introduces an additional connection which, if improperly made, will increase the resistance.



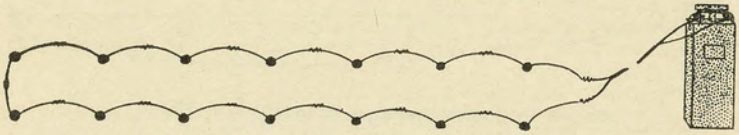
SHOWING USE OF DUPLEX LEADING WIRE

Some blasters prefer a slightly different method of making connections which obviates the use of connecting wire in connection with duplex leading wire. It takes one less connection, but is somewhat more expensive on account of requiring longer electric blasting cap wires and demands the closest attention in order to get a good circuit.



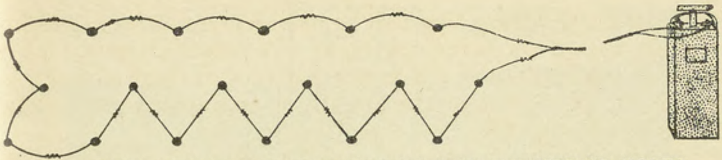
ANOTHER METHOD OF CONNECTING DUPLEX LEADING WIRE

An excellent method of making a series connection where two lines of holes are used is shown in the following sketch. This is of especial advantage when using two lines of holes with delay electric blasting caps or delay electric igniters and in blasting wide ditches. Either single or duplex leading wire may be used.



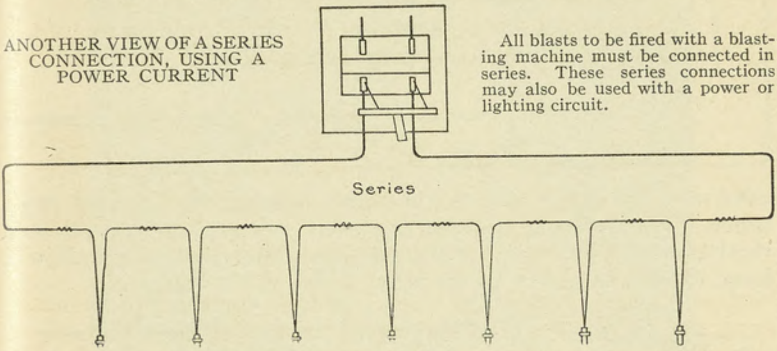
SHOWING HOW TO MAKE A SERIES CONNECTION WHEN THERE ARE TWO LINES OF HOLES

How three lines of holes for the use of delay electric blasting caps or delay electric igniters or for very wide ditch blasts may be connected in series is shown in the following diagram. Either single or duplex leading wire may be used.



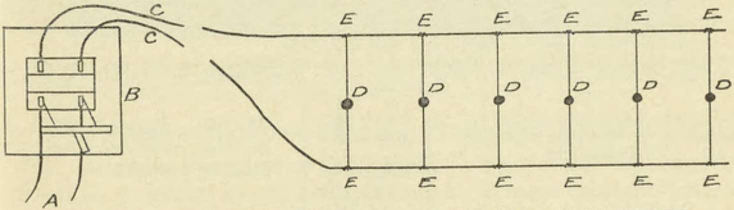
SHOWING METHOD OF CONNECTING THREE LINES OF HOLES

ANOTHER VIEW OF A SERIES CONNECTION, USING A POWER CURRENT



All blasts to be fired with a blasting machine must be connected in series. These series connections may also be used with a power or lighting circuit.

Parallel Connections.—When power or lighting circuits are used for firing, the detonators may be connected in parallel. This type of circuit differs materially from the series circuit, and is shown graphically in the accompanying cut. For such a circuit, the firing current must have 1½ amperes for each detonator or squib, but the voltage of the current can be less than when the same number of detonators is connected in series.

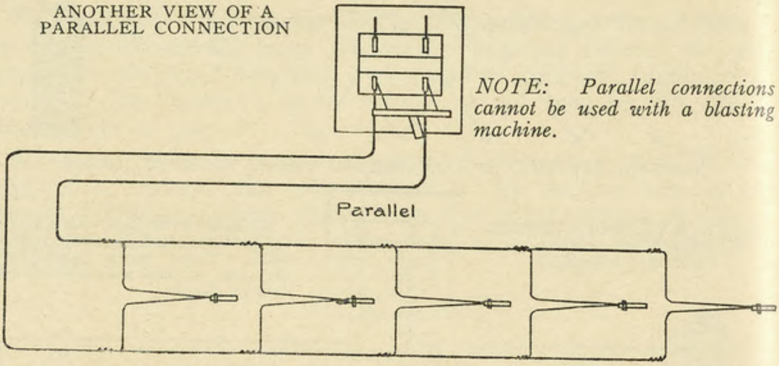


SHOWING PARALLEL METHOD OF CONNECTING WHEN POWER OR LIGHTING CIRCUIT IS USED

A. Power or lighting circuit. B. Blasting switch for closing circuit.
C. Leading wires of sufficient length to keep the switch B a safe distance from the blast and to reach past the last hole to be fired.
D. Bore holes with electric detonators.
E. Connections between the detonator wires from holes D to the leading wire C.

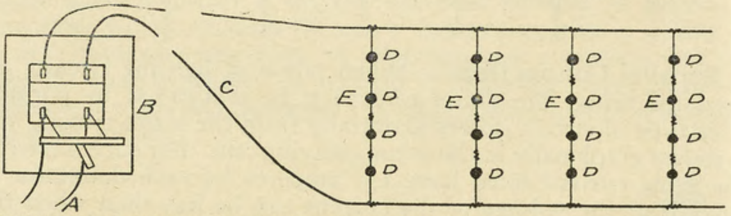
Parallel Series Connections.—A circuit connected in parallel series is a number of series circuits, two or more, connected in parallel as is shown in the accompanying diagram. This type of circuit can be used only with a power or lighting current. Such a circuit requires 1½ amperes for each series, shown as E, but the voltage required is less than the amount required to

ANOTHER VIEW OF A PARALLEL CONNECTION



NOTE: Parallel connections cannot be used with a blasting machine.

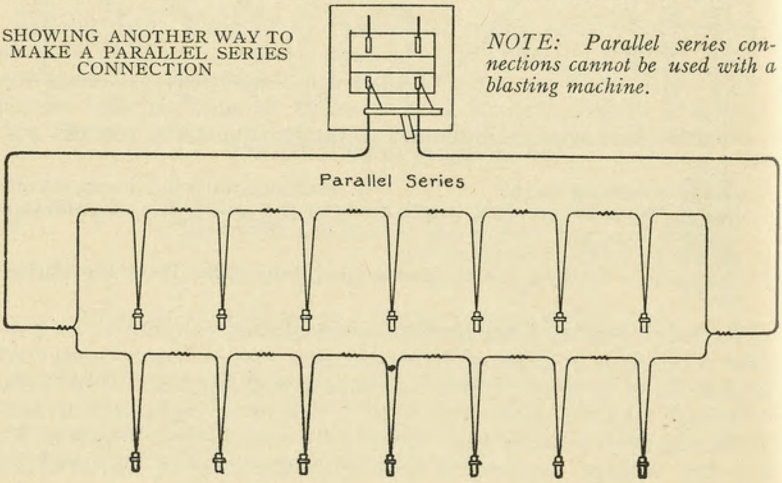
overcome the resistance in the series having the greatest resistance. The determination of this point is a slightly complicated mathematical problem for the blaster, and it is best to allow a large margin of safety in the way of too much voltage.



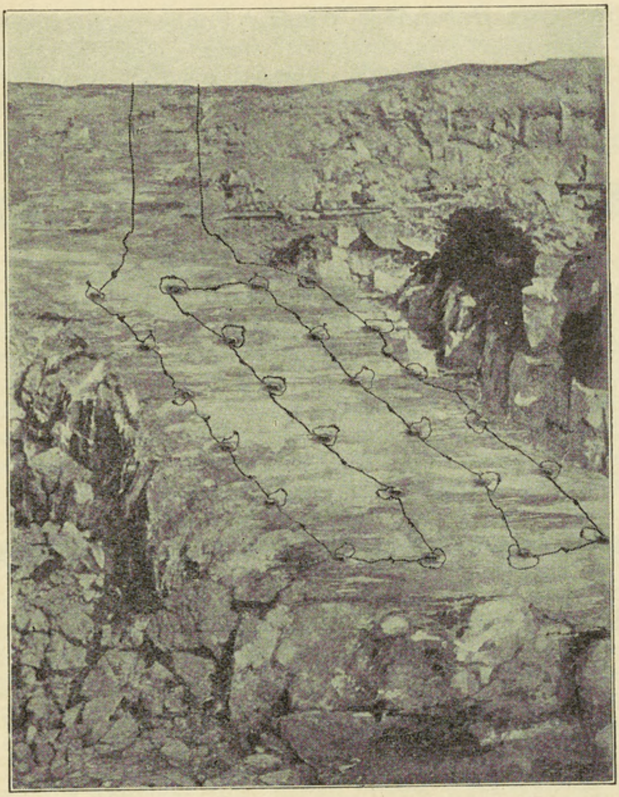
SHOWING PARALLEL SERIES CONNECTION HAVING TWO OR MORE SERIES

A. Wires of power or lighting circuit. B. Blasting switch for closing circuit.
C. Leading wires of sufficient length to keep the switch B at a safe distance from the blast and to reach past the last hole.
D. Bore holes with electric detonators. E. Individual series of holes D.

SHOWING ANOTHER WAY TO MAKE A PARALLEL SERIES CONNECTION



NOTE: Parallel series connections cannot be used with a blasting machine.

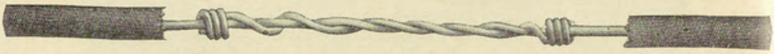


Twenty-four holes with two electric blasting caps in each hole—48 electric blasting caps in all—connected in series. The blast should be fired with a No. 3-A du Pont Blasting Machine, or with a power or lighting circuit of 110 volts and 1½ amperes

Making and Protecting Wire Connections

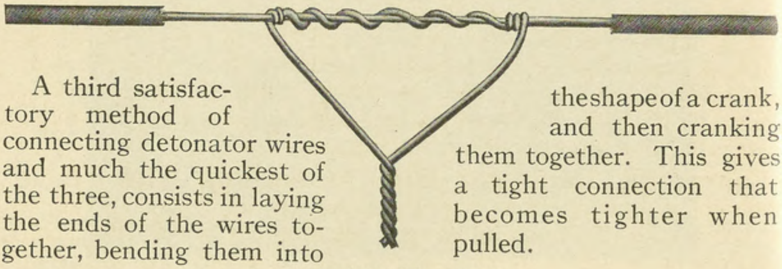
The wiring or connecting of an electric blast must be very carefully done to insure success. It is true that mere contact between perfectly clean wires is sufficient to permit the passage of the current, but it is almost impossible to get the wires perfectly clean, and the joint should, therefore, be made in such a manner as to bring together a considerable length of the wire, after it has been cleaned as thoroughly as possible. This preliminary cleaning or scraping should never be neglected. There is sure to be tar or grease present from the waterproofing material used, as well as oxides, dirt and foreign material that has adhered to the wire. Connecting a blast involves three steps: connecting the detonator or squib wires together, either directly or by means of connecting wire; connecting the proper detonator wires to the leading wire; and connecting the leading wire to the blasting machine or power switch.

Connecting Detonator Wires.—Connections between detonator wires or between detonator wires and connecting wires may be made by several methods. The one generally recommended is known as the Western Union twist, such as is shown in the sketch directly below. Such a twist should be tightly made to keep the resistance in the joint down to a minimum. If there is no bare end to the connecting wire, skin off about two inches of the insulation. A later paragraph will give detailed information about protecting these bare joints.



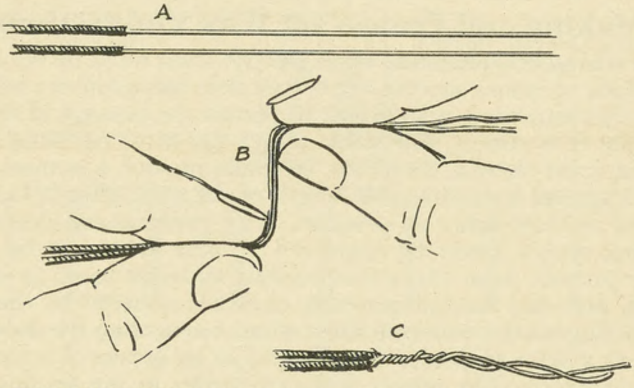
WESTERN UNION TWIST

Another good way to make a joint if one has pliers at hand is that shown in the next illustration. This is made in the same manner as the Western Union twist except that the ends are left long and twisted together.



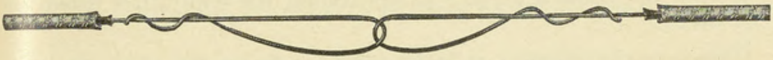
ANOTHER GOOD JOINT

A third satisfactory method of connecting detonator wires and much the quickest of the three, consists in laying the ends of the wires together, bending them into the shape of a crank, and then cranking them together. This gives a tight connection that becomes tighter when pulled.



CONNECTING DETONATOR WIRES. THE TINNED ENDS ARE LAID CLOSE TOGETHER (A), BENT INTO THE SHAPE OF A CRANK (B), AND CRANKED TOGETHER TO FORM A TIGHT CONNECTION (C)

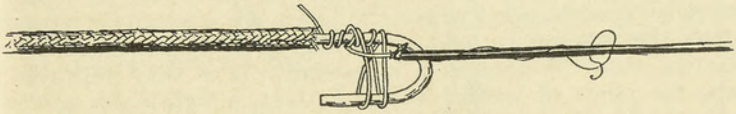
Under no circumstances should wires be merely looped together as shown below:



LOOPED WIRES—A VERY POOR ELECTRICAL CONNECTION

It is best not to have any more joints in the circuit than are absolutely necessary. Joints are especially objectionable in electric detonator wires in the bore hole. These wires should be long enough to reach out of the bore hole without being spliced. It is even better to have them long enough to connect directly with the wire of the electric detonator in the adjoining bore hole, thus avoiding the use of connecting wire as well as saving time. When connecting wire is required, *old electric blasting cap wire* that is full of joints and bruises from having already been through a blast *should not be used.* Use new connecting wire. The use of old, damaged electric blasting cap or connecting wire is the worst kind of false economy. No experienced contractor needs to be told how expensive it is to have a long period of delay after the men have been ordered away from the work, while the blaster pokes around looking for the "reason why the shot did not go," all men, horses and machinery idle meanwhile.

Connecting Detonator Wire to Leading Wire.—It is much easier to connect wires of the same size than wires of different sizes, as are leading and electric blasting cap wires. For such connections, a joint like that shown next is good—the spring of the thick wire keeping up a tension on the small wire, and causing it to make a good contact. To make this, wrap the detonator or connecting wire tightly around the end of the leading wire about one inch from the end. Then bend the end of the leading wire back sharply and take a turn or two of the detonator wire around the loop. This last loop is simple to make a stronger connection to withstand any accidental pull on the leading wire that might tear the connection loose. It is difficult to make a neat joint in this way but it can be made good electrically if the wires are first thoroughly cleaned.



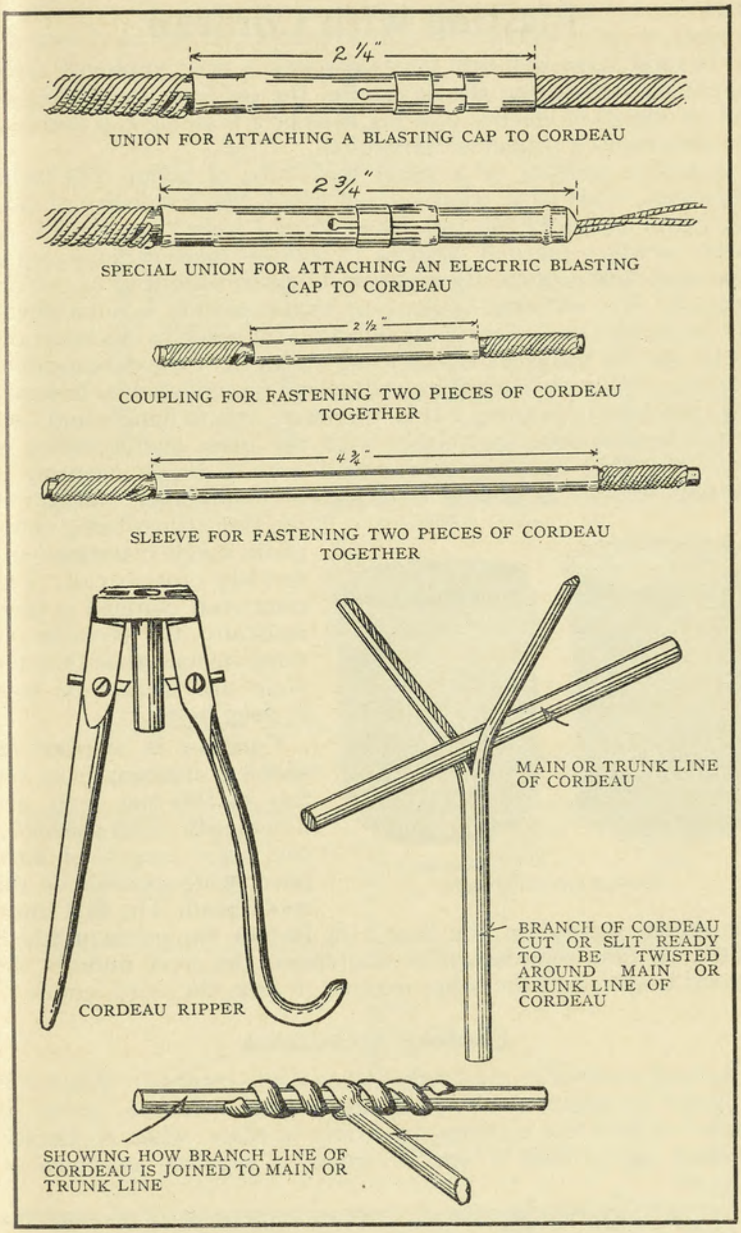
AN EXCELLENT METHOD OF CONNECTING AN ELECTRIC BLASTING CAP WIRE TO A LEADING WIRE

Connecting the Leading Wire to Blasting Machine or Power Switch.—The connection of the leading wire to the blasting machine is made by loosening the wing nuts on the two binding posts, inserting the ends of leading wire into the small holes in the binding posts and tightening the wing nuts down on the wires.

When power current is to be used for firing the shot, the connection is made by winding the ends of the leading wires around the binding posts on the dead end of the firing switch.

If it becomes necessary to mend breaks in the leading wire or to splice it to make it longer, the joints should be made with special care. Those in the connecting and electric blasting cap wires, as a rule, have to do service only for a few minutes or hours; but those in the leading wire will be there while the leading wire lasts and if poorly made will give trouble long after their location is forgotten. Such joints should be made according to the first method recommended for the electric blasting cap wires, except that these joints should be about 2 or 3 inches in length. *It pays* to have joints in the leading wire *soldered*. Some of the most peculiar and erratic troubles are due to defective joints in leading wire, which worked satisfactorily for a number of shots, but afterwards became bad through corrosion having formed between the contact surfaces. The electrical condition of such a joint is likely to change on the slightest movement of the wire, to be good one minute and bad the next, and for that reason to cause a trouble difficult to locate.

Protecting Bare Joints.—The naked joints in the wires of a blasting circuit must always be protected against short circuiting, especially through water. This is done in several ways. When connections lie on moist ground they may be held up by supporting them on stones, blocks or sticks so that only the insulated parts of the wires touch the ground and supports; or the joints may be insulated with tape. While not generally needed where the joints can be held off the ground, the taping of joints is strongly recommended where the joints are covered by tamping, where they cannot be held out of the water on props, and where blasting must be done in a rainstorm. It is very desirable to tape the joints of leading wire. In fact, a well-made, soldered and taped joint puts the leading wire in almost as good condition as when new, while a few questionable joints are sure at some time to be a source of annoyance, delay and danger.


2 1/4"
2 3/4"
2 1/2"
4 3/4"
MAIN OR TRUNK LINE OF CORDEAU
BRANCH OF CORDEAU CUT OR SLIT READY TO BE TWISTED AROUND MAIN OR TRUNK LINE OF CORDEAU
SHOWING HOW BRANCH LINE OF CORDEAU IS JOINED TO MAIN OR TRUNK LINE

UNION FOR ATTACHING A BLASTING CAP TO CORDEAU

SPECIAL UNION FOR ATTACHING AN ELECTRIC BLASTING CAP TO CORDEAU

COUPLING FOR FASTENING TWO PIECES OF CORDEAU TOGETHER

SLEEVE FOR FASTENING TWO PIECES OF CORDEAU TOGETHER

CORDEAU RIPPER

CORDEAU ACCESSORIES AND HOW THEY ARE USED.
METHOD OF JOINING CORDEAU

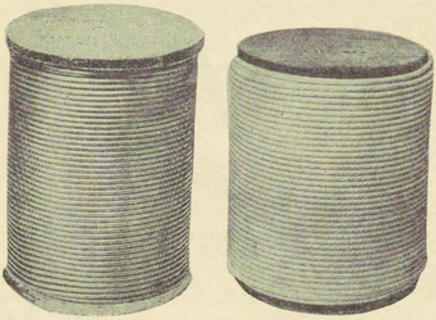
Blasting with Cordeau

In most large well-drill blasts cordeau is now employed as the agent for detonating the dynamite the cordeau itself being set off by means of electric blasting caps or a b'asting cap and fuse, or sometimes a primer of dynamite.

Cordeau consists of a small lead tube of about .229 inches diameter, filled with trinitrotoluol which has a velocity of detonation of about 17,500 feet (more than 3 miles) per second. In other words, a piece of cordeau 17,500 feet long, if detonated at one end, will explode throughout its entire length in about one second. The extreme violence of this explosion is sufficient to detonate high explosives lying alongside the cordeau in a bore hole.

In spite of the great velocity and strength of the detonation of cordeau, it is very insensitive and cannot be exploded by hammering, pinching or burning. It is, therefore, safe to handle and load.

Cordeau is furnished either with the plain lead covering or with the lead covering surrounded with a single covering of cotton, or with a double covering or "countering" of cotton, the three types being called plain, single countered and double countered. The countered cordeau is more resistant to abrasion of tamping materials than the plain and should be used in deep holes.



Plain Countered
SPOOLS OF CORDEAU

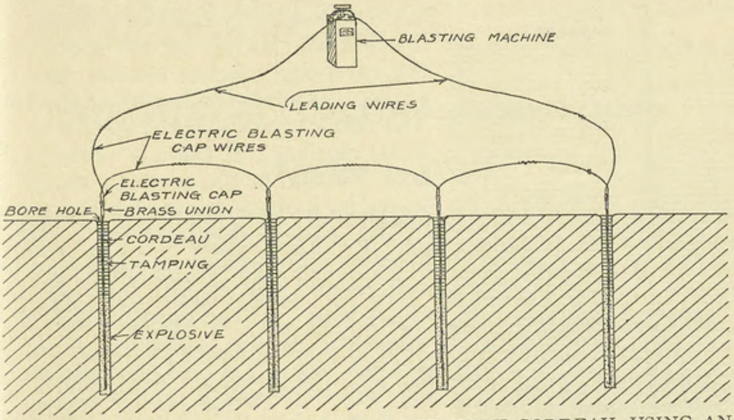
Cordeau is shipped on spools containing from 100 feet to 500 feet each, not necessarily all of one length, the exact length of each piece being specified on the spool head. The first number shown represents the length in feet of the cordeau which would be first removed from the spool, the next number the second length, and the other number, if any, the third length.

Cordeau Accessories

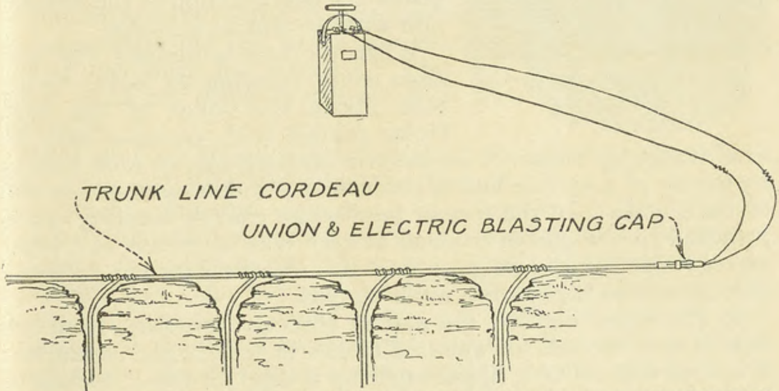
Several accessories are needed when using cordeau. When it is exploded by means of a blasting cap and safety fuse, a "union" is needed to hold the blasting cap firmly in place; when an electric blasting cap is used a "special union" is required as shown on page 61.

For splicing two lengths of cordeau together a brass coupling is used. A longer sleeve for making a stronger splice is shown on page 61.

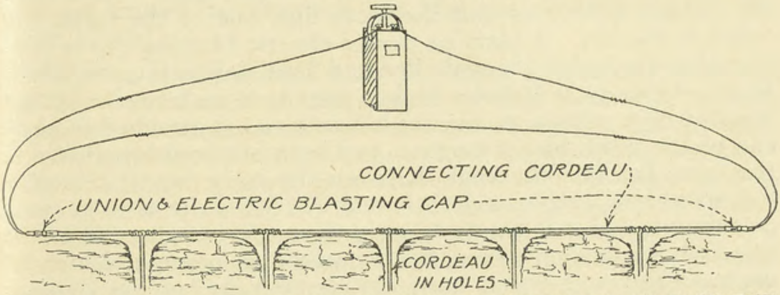
The cordeau ripper is a special tool for ripping or splitting the cordeau at the end when making a connection between a branch or bore hole line and a surface main line as described on page 64.


BLASTING MACHINE
LEADING WIRES
ELECTRIC BLASTING CAP WIRES
ELECTRIC BLASTING CAP
BRASS UNION
BORE HOLE
CORDEAU
TAMPING
EXPLOSIVE

METHOD OF WIRING FOR A BLAST FIRED WITH CORDEAU, USING AN ELECTRIC BLASTING CAP OVER EACH BORE HOLE AND NO TRUNK LINE OF CORDEAU

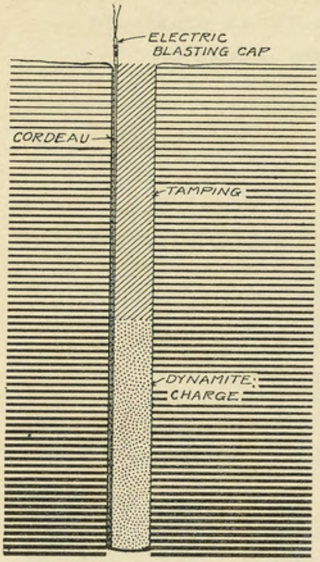

TRUNK LINE CORDEAU
UNION & ELECTRIC BLASTING CAP

CORDEAU CONNECTION WITH AN ELECTRIC BLASTING CAP AT ONE END OF MAIN LINE CORDEAU


CONNECTING CORDEAU
UNION & ELECTRIC BLASTING CAP
CORDEAU IN HOLES

TRUNK LINE OF CORDEAU WITH ELECTRIC BLASTING CAP AT EACH END

Priming Holes with Cordeau



POSITION OF CORDEAU IN BORE HOLE

The end of the cordeau is tied to or laced through a dynamite cartridge and it is allowed to run off the spool until the cartridge reaches bottom and the cordeau extends full length of the hole. The rest of the charge is loaded in the usual manner. If there is water in the hole, the end of the cordeau should be sealed by hammering the lead together.

The load of dynamite in well-drill holes may be broken as many times as desired and still require only one line of cordeau. If the cordeau is broken while loading the explosives, no harm is done, but if it is broken while tamping, some dynamite should be loaded at that point and the tamping continued. The dynamite so loaded will assure the continuation of the detonation with no fear of a misfire.

When the hole is tamped, the cordeau is cut allowing six inches to extend above the collar of the hole. Holes primed with cordeau may be fired either by means of an electric blasting cap at each hole or by means of a surface line of cordeau with a detonator at one end or both ends. In the former method an electric blasting cap is attached to the end of cordeau at each hole by means of a brass union made for the purpose and the electric blasting caps are connected and fired in the usual manner.

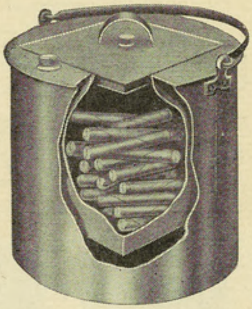
In the latter method the end of cordeau extending from the hole is split in half for about 3 inches in length and separated. A special tool called a ripper or slitter is used for this. A main or trunk line is laid along the top of holes on the surface so that the main line lies in the crotch formed by the split ends. These ends are twisted tightly around the main line, one to the right, the other to the left. A blasting cap or electric blasting cap is connected to the end of the main line and fired, detonating the whole blast. As many as 76 holes 86 feet deep have been fired with one blasting cap. Often an electric blasting cap is attached to each end of the trunk line of cordeau and both are fired together. If this is to be done the angle between the main line and branch line should be a right angle, whereas if a detonator is to be used at only one end it is better to have the angle between the trunk line and the branch facing the detonator an angle of about 45 degrees. The connections must always be tight and the detonators so placed that the direction of the detonating wave will be from the trunk line into the slit branch line, never from the slit branch line against the lead casing of the main line. The explosive in the tube will not detonate if wet and therefore extreme care is necessary to protect surface connections from water.

Additional Blasting Accessories

Thawing Kettles

Most high explosives are today manufactured on a low-freezing formula, and will not freeze at any temperature normally encountered in this country. Therefore, the hazardous process of thawing dynamite has been almost entirely done away with. Only in case explosives have been subjected for some length of time to an abnormally low temperature will thawing equipment be needed.

Du Pont Thawing Kettles are all made in one piece with a water-tight compartment for the explosives, which is surrounded by the receptacle for the hot water used to furnish the heat for thawing. This hot water must not come in contact with the dynamite.


DU PONT THAWING KETTLE

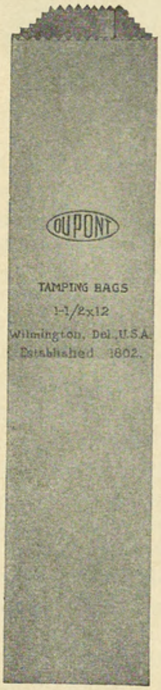
While du Pont Thawing Kettles will retain their heat and keep the explosive thawed for a considerable time, depending, of course, on the nature of the weather, this effective period can be increased to about five times as long if the warm kettle is kept in a barrel or box with dry hay surrounding it. This hay can be held in place by a cylinder of wire screen, so that the thawing kettle can easily be removed and replaced. If the barrel be mounted on two wheels with a tongue attachment, the dynamite can be readily drawn from point to point about the outside work without being exposed to the cold air until it is to be loaded in the bore hole. The explosive may also be kept thawed by wrapping old blankets or sacks around the warm kettle.

Under no circumstances must the water be heated in thawing kettles, even though the explosives be first removed, because nitroglycerin exudes readily from warm dynamite, and enough of it is likely to be found in the bottom of the explosives compartment of a thawing kettle that has been in use for some time to cause a serious accident if the thawing kettle should be placed over a fire. It is necessary to heat the water in something else before filling the water jacket. *The hot water must always be tested before filling the dynamite compartment. If it is hot enough to burn the hand, do not put the explosives into the thawing kettle.* Never fill the water jacket unless the explosives compartment is empty. See that the explosives compartment is perfectly dry before it is filled.

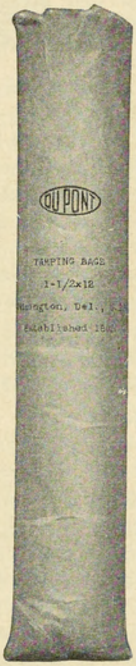
Thawing kettles should be kept clean at all times. Should any of the explosive compounds leak out, the explosives compartment should be thoroughly cleaned with a solution of sal soda.

Capacities and Dimensions of Thawing Kettles

	Capacity	Weight Empty	Weight of Water	Total Weight Filled	Outside Dimensions
Du Pont No. 1.	30 lbs.	12½ lbs.	40 lbs.	82½ lbs.	14″ x 14½″
Du Pont No. 2.	60 lbs.	17½ lbs.	77½ lbs.	155 lbs.	17½″ x 21″



TAMPING BAG
(Empty)



TAMPING BAG
(Full)

Tamping Bags

Tamping bags made of heavy paper are used in many places as containers for sand, clay or loam for stemming. They are a great convenience to miners for they save time and trouble in loading bore holes, particularly those pointing upward. Through the better tamping of the shot where tamping bags are in use, they often save many times their cost in economy of explosives.

Tamping bags are also employed as containers for blasting powder when the miner or blaster desires to make up the charge in cartridge form, as is generally the custom when it is used in mines, in open work that is damp, and in holes pointing upward.

Tamping bags are made approximately two inches longer than shown in the table on page 67 in order to provide for folding at the end when filled.

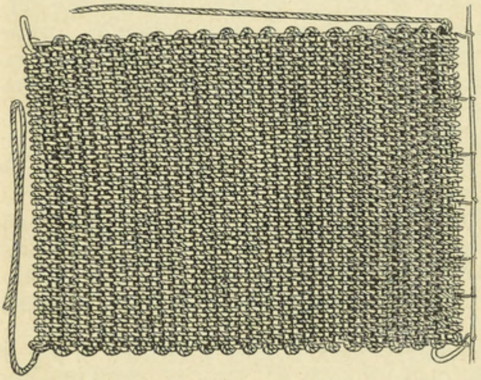
Tamping bags are put up in bundles

of 500 each, and packed ten bundles to the bale. They are manufactured in the following sizes:

Size No.	Size	No. in Bale	Shipping Weight per Bale
A	1″ x 8″	5000	28 lbs.
B	1¼″ x 8″	5000	31 lbs.
C	1¼″ x 10″	5000	37½ lbs.
D	1¼″ x 12″	5000	45 lbs.
E	1½″ x 8″	5000	36 lbs.
F	1½″ x 10″	5000	44 lbs.
G	1½″ x 12″	5000	48 lbs.
H	1½″ x 16″	5000	62 lbs.
J	2″ x 18″	5000	86 lbs.

Blasting Mats

Blasting mats are closely woven mats of hemp or wire rope. They are used over blasts or between blasts and property to catch or hold material flying from the blasts. Hemp rope is generally used and is considered the best, although steel wire rope has been tried with success. The mats are made of 1 inch, 1¼ inch or 1½ inch rope, according to the demands of the customer. They are not carried in stock, but are woven on order and are made in any size required. If the blasting mats are to cover light charges of explosives, they may be spread directly over the bore holes; but if heavier charges are used, railroad ties or logs should be put down first and the mats on top of them. Sometimes the mats are propped on lightly supported uprights several feet above the blast, so that when the blast is fired the flying rock is stopped by the under side of the mat.



A HEMP BLASTING MAT

These arrangements are very effective in preventing the rock from being thrown into the air and should always be adopted when blasting is done near thoroughfares or buildings. Boards and logs alone are not sufficient.

Elementary Electrical Principles Applicable to Detonation of Explosives

1. In Fig. 1 is shown an ordinary dry cell battery, with its two binding posts or connectors (A-B). These are called, respectively, the positive and negative poles.

If the poles are connected with a piece of wire (C) an electric current will flow through it, in the direction indicated by the arrows, and will continue to flow until the chemicals are exhausted.

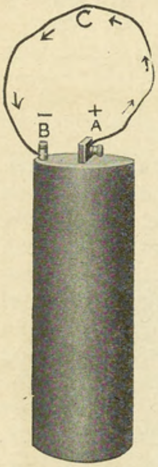


Fig. 1

2. Such a wire affording a path for the current from the positive to the negative pole of a battery is called a circuit. The current flows only when the circuit is complete, and a single break in the continuity of the wire stops the flow of current throughout the entire circuit.

The wire comprising the circuit can be much longer than shown in Fig. 1—even many miles in length—and still the current will follow it throughout its entire length, as long as some shorter or easier path between the two poles is not offered. If the wire is covered with some insulating material like silk, rubber or cotton, so as to prevent the current from escaping from it and following some shorter or easier course, then the wire may be wound many times around other objects, or make any number of bends and twists, and still the current will follow it from one pole of the battery to the other, with almost as much ease as it did the short piece of wire in Fig. 1.

3. Now, how do we know that a current is flowing through the wire in the manner described? We know it *by its effects*, and a few of these effects, which are of great importance in understanding blasting by electricity, will answer for the present consideration.

a. First, if part of the ordinary thick copper wire used in Fig. 1 be replaced by a very fine piece of wire (G, Fig. 2), the fine wire being preferably of iron, platinum or German silver, then the difficulty which the current has in passing through this small piece of wire, or, as electricians say, "overcoming its resistance," will transform part of the current into heat. The fine wire will become red hot, and even melt if the current is strong. This is the principle made use of in firing electric blasting caps. Another familiar application is the incandescent electric light, where a fine carbon or tungsten wire is forced to carry a large amount of current, and becomes so intensely white hot (incandescent) that it gives out light.

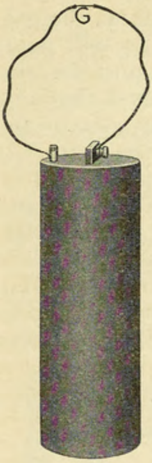


FIG. 2

b. Second, if wire insulated with cotton or silk* be wound many times around a bar of ordinary soft iron (Fig. 3), the ends of the wire being connected with a battery so that the current will flow through it, the iron bar will become powerfully magnetic. As soon as the circuit is interrupted† at any point, whether by removing one or both wires from the battery, or breaking or cutting the wire anywhere throughout its length, nearly all the magnetism‡ immediately departs from the iron. As soon as the circuit is closed, the magnetism returns, even though the opening and closing of the circuit is performed many times a second and the point of interruption is in a far distant part of the circuit. If another piece of iron for the magnet to attract is balanced by a spring over the magnet, every time the circuit is closed it will be drawn toward the magnet, and when the circuit is opened the spring will draw it away. Such a piece of iron provided for the magnet to act upon is called an armature. The telegraph sounder (Fig. 4) works on this principle, the armature in its up and down movements causing a lever to strike resonant metal pegs, which give out the familiar clicks, by the sound of which the operator reads the message. Many other electrical instruments also work on this same principle.

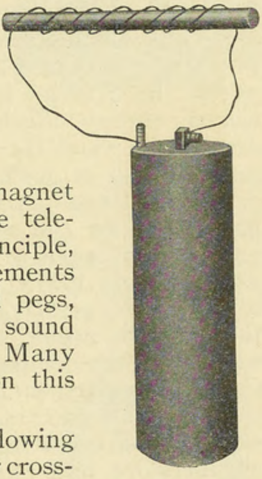


FIG. 3

c. Third, that an electric current is flowing through the wire (Fig. 1) can be shown by crossing part of the wire over a compass as in Fig. 5.

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*Non-conductors are those substances which do not carry the electric current. Conductors are those substances which carry it readily; poor conductors are those which carry it, but with difficulty. Strictly speaking, there are no perfect non-conductors, and no perfect conductors; but the terms are in common use and are convenient and unobjectionable if it is borne in mind that they are relative. Metals are the best conductors. Silver heads the list, followed in turn by copper, zinc, iron, platinum, lead, mercury, etc. Among the best non-conductors are glass, rubber, sulphur, silk, cotton, paraffin, tar, resinous materials, oils, etc. Water is a representative of poor conductors, but its conductivity is greatly increased when various salts, such as those likely to be derived from rocks in drilling, are dissolved in it. Acids also increase the conductivity of water.

†Interrupting or breaking a circuit at any point is referred to by electricians as "opening" the circuit; re-establishing it, so that the current can pass, as "closing" the circuit.

‡Soft iron readily loses nearly all its magnetism as soon as the current stops, and the softer the iron the more readily it becomes demagnetized, although it never loses all of it. Hard steel, on the contrary, retains a great deal of magnetism once it has been magnetized, and on this principle depends a permanent magnet. The magnetism left in an electro-magnet after the current has ceased is called "residual magnetism."

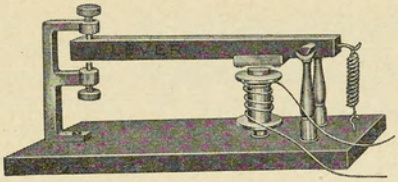

Fig. 4

Ordinarily, of course, the needle of the compass will point north and south, and the wire above it should run in the same direction. But as soon as the connection with the battery is established the needle will be deflected, so that it will stand at right angles to the wire, or, in other words, point east and west. If the end of the wire that is connected with the positive pole of the battery be transferred to the negative pole, and *vice versa* (that is, if the "poles be changed") the *needle will reverse its direction*, so that the end which pointed east before will now point west.

4. The needle will also reverse its direction if the wire C, Fig. 5, be moved from its position above the needle to one below it, as shown by the dotted line. In other words, the direction of the electric current affects the direction in which the magnetic needle is deflected, deflecting it one way when passing above the needle and in the opposite way when passing below it. This fact enables us to intensify very greatly the action of the current upon the magnetic needle, by putting a coil of insulated wire about the compass, as shown in Fig. 6. With such an arrangement, all the strands of wire above the needle are carrying the current in one direction and all those below in the opposite direction. They all, therefore, tend to deflect the needle in the same manner, and the effect is very greatly magnified; so much so, that an instrument constructed on this principle indicates the passage of currents that are too feeble to be detected by any other means. Such an instrument is called a galvanometer.

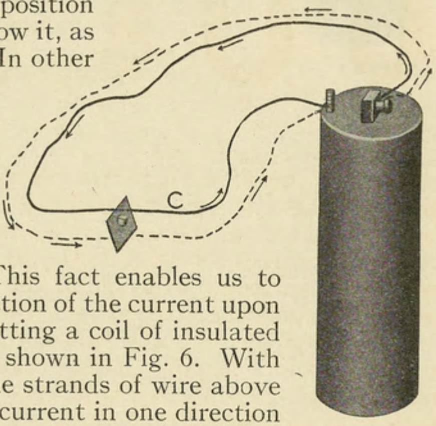

Fig. 5

5. *Practical Magnets.*—The electro-magnet is much more powerful when, instead of the wires being wound on a straight bar as in Fig. 3, the bar is bent U-shape, as shown in A and B, Fig. 7, for in this position both ends can be made to act at once upon the same piece of iron, and they can attract it with double, or more than double, force. It is also found that the wire in the middle of the electro-magnet does not have as much of an effect as that near the ends, and for this reason the

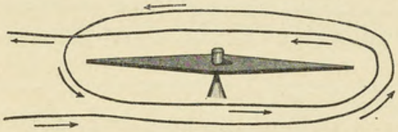

Fig. 6

wire is not generally wound on the middle part, but only on the ends, as shown in B, Fig. 7. Again, it is ordinarily advantageous, from the manufacturing standpoint, to make the iron core of a magnet in sections, afterwards fastening them together, as shown in C, Fig. 7. The sections H-I can then be wound with the wire, just as thread is wound on a spool, securing great efficiency as well as ease in manufacture (D, Fig. 7).

Such electro-magnets, when of large size and actuated by powerful currents, are of tremendous power, and will lift masses of iron weighing tons.

6. If a piece of soft iron, *i. e.*, an armature (paragraph 3-b, page 69), be placed between the poles of a conveniently shaped magnet, as shown in Fig. 8, the piece of soft iron is also caused to become magnetic. North polarity is induced in the end near, or in contact with, the south pole, and *vice versa*. If the position of the armature is reversed, so that the end A is nearest the south, and B nearest the north pole of the magnet, then the armature reverses its polarity, so as always to present its south end to the north end of the controlling ("field") magnet. This it does, even though the reversal of ends is very rapid, such as would result from fixing a shaft into the armature at J, and rotating it rapidly in the direction shown by the arrows.

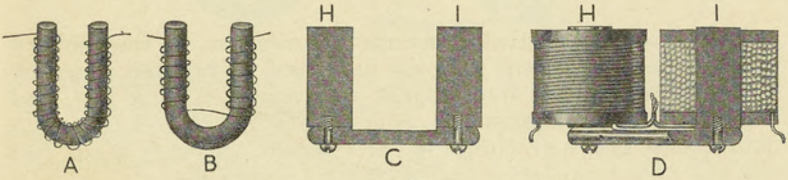

FIG. 7

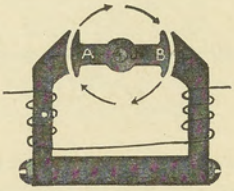

FIG. 8

We have seen (paragraph 3-b, page 69) that passing an electric current through wire wound upon a soft iron bar is capable of causing it to become magnetic. The reverse of this proposition, namely, the induction of an electric current in the wire about an iron bar by causing the bar to become magnetic, is also true with certain limitations. Take such a bar wound with wire (A, Fig. 9) and connect the ends of the wire with a galvanometer (the construction of which is explained in paragraph 4, page 70), so that we will know whenever a current passes. Now cause the end of the bar to approach the live electro-magnet B, Fig. 9. All the time it is approaching B, the galvanometer shows that an electric current is passing. When the movement is stopped, the current stops.

If the movement be reversed, that is, if the wire-wound bar be moved away from the magnet, the galvanometer will again show that a current is passing, but *in the opposite direction.*

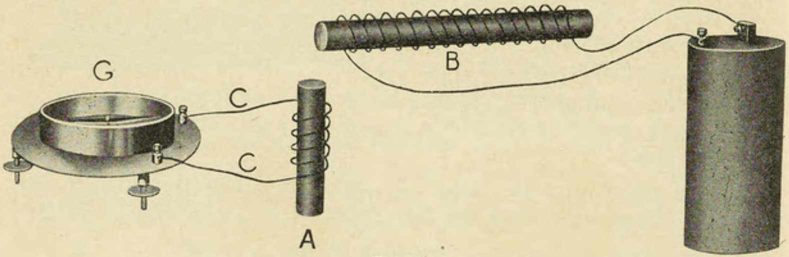

Fig. 9

The reason the current is set up (induced) in the wire around the iron bar is that the iron bar is caused to become magnetic as it approaches the live magnet (paragraph 6, page 71), and loses this induced magnetism as it is withdrawn; and there is a natural law that *any change in the magnetic condition of an iron core will induce an electric current in wire around it.*

It may be argued that the result is not an electric current, but a series of electric pulsations. That is perfectly true; but if the pulsations are sufficiently frequent, through rapid rotation of the armature shaft, they produce similar enough effects to the steady flow of a battery current to be available for most purposes.

But the currents induced in the armature do more than pulsate. If the ends of the armature wire are connected with a galvanometer and the armature is slowly revolved so that the movements of the needle can be watched, the needle will be found to swing first to the east, then to the west, then east, then west again, changing direction with each half revolution of the armature. If the end of the galvanometer needle should be equipped with a pen, so that it could make a mark on a paper tape moved steadily beneath it by clockwork, the tracing that would be obtained by this experiment would look like Fig. 10.

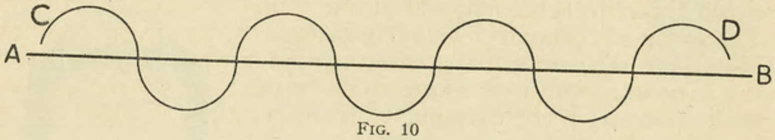

Fig. 10

In this illustration, Fig. 10, the straight line A B is the mark the pen would make if the paper were moved forward with the needle at rest and pointing to zero, or north. The wavy line C D is the mark made by the needle when such a current, continually reversing its direction, is sent through the apparatus. Such a current is called an *alternating current.*

But it is evident from what has already been said (paragraph 4, page 70) that such an alternating current would not do to energize the field magnet. In order to maintain the constant polarity of the field magnet, the current supplying it with energy must be in one direction, like the battery current. This is called a *direct current*. The alternating current induced in the armature is, therefore, rectified or changed into a direct current by means of the *commutator* (Fig. 11).

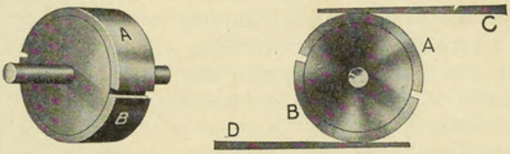

FIG. 11

The commutator in the blasting machine consists of a cylinder of hard fiber or rubber, covered with copper, and mounted on the same shaft which drives the armature. The copper is cut lengthwise into two sections (A and B, Fig. 11). These are firmly attached to the surface of the hard fiber very close together, but not touching; that is, they are insulated from each other by the fiber which carries them. One end of the armature wire is connected with section A, the other with section B.

The current is taken off of the commutator for use by copper brushes, C and D (Fig. 11). Now, as the commutator revolves with the shaft, while the brushes remain stationary, the section A is in contact with brush C for half a revolution, then with brush D for the other half. The same thing happens to section B. Therefore, the effect of the commutator is to change the alternating armature current into a *direct current*, and the tracing which the recording galvanometer will make on the tape, when it receives the current from the dynamo equipped with the commutator, is shown in Fig. 12.

The alternating current would fire electric blasting caps as well as the direct current; but if it were not converted into a direct current as it is, we would either have to energize the field magnet with a battery or use a permanent magnet. With the present arrangement, we simply lead the rectified current from the armature through the wire on the field magnet, which is thus energized

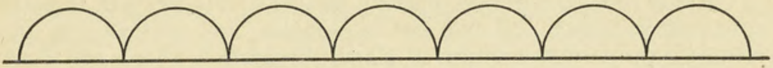

FIG. 12

by the current from its own armature. At the start, the very slight residual magnetism which is retained by the field magnet (see note ‡, paragraph 3-b, page 69) is sufficient to set up a feeble current in the armature. This in turn makes the field magnet stronger, and the stronger field magnet develops a stronger current in the armature. Thus the machine "builds up," as it is called, until after a few revolutions it is working at its full power. You can notice this when you push down the rack bar of a blasting machine. The first part of the stroke is easy, but after the armature has made a few revolutions it pushes quite hard, because the magnet has become strong and pulls back on the armature, tending to resist our efforts to turn it.

The dynamo just described, which is used in most American blasting machines, is one of the simplest and earliest forms of dynamo. Those used for generating powerful currents for electric lighting and power are more complicated, and more efficient electrically than those made on this simple design; that is, if the blasting machine dynamo were constructed on modern principles it would take less power for the same output of current or give greater output with the same amount of power, whichever way one chooses to look at it. But, for the purposes to which a blasting machine is put, considerations of simplicity outweigh this kind of efficiency. Blasters would rather exert a little more muscle in operating the blasting machine than pay for the increased cost of repairs to a more modern dynamo, not to mention the increased initial cost. Indeed, it is doubtful if a more satisfactory blasting machine could be reasonably asked for than the ordinary push-down blasting machine just as it is now made. Certainly no other piece of electrical machinery would stand the misuse to which many of these blasting machines are subjected in practice, and still continue to do good work, day after day and year after year, as many of them do in spite of it all.

Let us now dissect an ordinary blasting machine, as a review, and see how these electrical principles apply. Fig. 13 shows a three-post blasting machine. Note the field magnets 8 and 9 with their winding of coarse wire. In the figure the armature 16 can be seen with its winding of finer wire.

Note the brushes 20, bearing on the commutator just as already described, and see where the ends of the armature wire are soldered, each to its respective commutator section. On the other side is the rack and pinion ratchet movement, by which the downward thrust of the rack bar I imparts rotary movement to the armature. This is so simple that any one can see at a glance how it works, and it need not be dealt with here.

There is one part of the blasting machine, simple, but of great importance, which has not yet been taken up, and that is the "shunt," sometimes called the "circuit breaker." This is the brass contrivance 4 placed in the bottom of the box. It is really nothing but a brass spring which makes contact with the bridge 5, when in its normal position, the parts which come in contact being covered with platinum, so that they will remain bright and make a good electrical connection.

The function of this shunt is as follows: The spring 4, called the contact spring, is connected by means of a piece of heavy copper wire to one of the binding posts, 26, representing one pole of the dynamo; the bridge is connected with the other binding post, representing the other pole of the dynamo. When the contact spring is up in contact with the bridge a short, easy circuit, called a shunt circuit, of practically no resistance, is offered for the electric current to pass from one pole to the other—in the language of the electrician, the dynamo is "short circuited." While the rack bar is being pushed down, the blasting machine is building up, the current generated passing across the shunt, so that by the time the rack bar is near the bottom of the stroke the dynamo is working at its maximum. When the rack bar strikes the contact spring, however, separating it from the bridge, the short circuit is broken, and the current of the dynamo has now no other way to pass from one pole to the other except by flowing out through the electric blasting cap circuit, and it does this just at the instant when it is at its maximum strength. The fine bridge wire in each blasting cap heats up instantly, causing all the caps to explode at the same time.

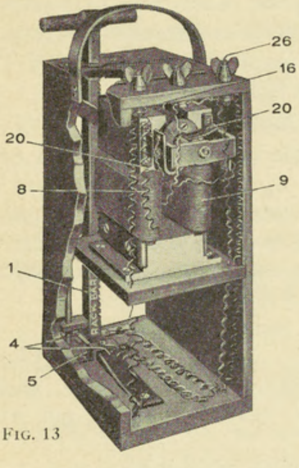

Fig. 13

Were it not for the shunt, operating as just described, current from the dynamo would begin to flow through the electric blasting caps as soon as one started to push down the rack bar. It would be a very weak current at first, gradually increasing with the building up of the blasting machine. Such a current is not well adapted to fire a number of electric blasting caps simultaneously, because it is impossible to make all of exactly the same degree of sensitiveness, and with the gradually increasing current, the more sensitive electric blasting caps would fire first, breaking the circuit and causing the less sensitive ones to miss. By employing the shunt, on the other hand, no current is sent out from the blasting machine until there is ample power to fire even the least sensitive.

Almost any one can use electric blasting accessories and obtain good results, merely by following general instructions. However, a study of the principles underlying their action, as explained in this section, will be a great aid in obtaining their highest possible efficiency. Again, when the man who understands the principles encounters difficulties, he knows how to overcome them, while the man who does not understand has to be helped out of his troubles.

General Precautions to be Observed with Regard to Explosives

DON'T forget the nature of explosives, but remember that with proper care they can be handled with comparative safety.

DON'T smoke while you are handling explosives, and DON'T handle explosives near an open light.

DON'T have matches about you while handling explosives.

DON'T shoot into explosives with a rifle or pistol, either in or out of a magazine.

DON'T leave explosives in a field or any place where animals can get at them. Cattle like the taste of soda and saltpeter in explosives, but there are other ingredients which would probably make them sick or kill them.

DON'T handle or store explosives in or near a residence.

DON'T leave explosives in a wet or damp place. They should be kept in a suitable, dry place, under lock and key, and where children or irresponsible persons cannot get at them.

DON'T store explosives so that the cartridges stand on end.

DON'T open cases of explosives in a magazine.

DON'T open cases of explosives with a nail puller, pick, or chisel.

DON'T use frozen or chilled explosives. All du Pont explosives except Carbonites 1, 2 and 3 and Blasting Gelatin are low-freezing.

DON'T thaw dynamite on heated stoves, rocks, bricks, or metal, or in an oven, and DON'T thaw dynamite in front of, near, or over a steam boiler or fire of any kind.

DON'T place a hot-water thawer over a fire, and never put dynamite into hot water or allow it to come in contact with steam.

DON'T put dynamite on shelves or on anything else directly over steam or hot-water pipes or other heated metal surface.

DON'T use two kinds of explosives in the same bore hole, except where one is used as a primer to detonate the other, as where dynamite is used to detonate du Pont Low Powder. The quicker explosive may open cracks in the rock and allow the slower to blow out through these cracks, doing little or no work.

DON'T force a primer into a bore hole.

DON'T do tamping with iron or steel bars or tools. Use only a wooden tamping stick with no metal parts.

DON'T explode a charge to chamber a bore hole and then immediately reload it, as the bore hole will be hot, and the second charge may explode prematurely.

DON'T explode a charge before every one is well beyond the danger zone and protected from flying débris. Protect your supply of explosives also from danger from this source.

DON'T hurry in seeking an explanation for the failure of a charge to explode.

DON'T drill, bore, or pick out a charge which has failed to explode. Drill and charge another bore hole at least two feet from the missed one.

DON'T keep electric blasting caps, blasting machines, fuse or blasting caps in a damp place.

DON'T leave detonators exposed to the direct rays of the sun.

DON'T leave detonators where the rays of the sun will strike them, particularly after passing through glass.

DON'T store or transport blasting caps or electric blasting caps with high explosives.

DON'T keep blasting caps or electric blasting caps in the same box or container with other explosives in the field. Keep them separate.

DON'T carry blasting caps or electric blasting caps in your pocket.

DON'T tap or otherwise investigate a blasting cap or electric blasting cap.

DON'T attempt to take blasting caps from the box by inserting a wire, nail, or other sharp instrument.

DON'T try to withdraw the wires from an electric blasting cap.

DON'T fasten a blasting cap to the safety fuse with the teeth or by flattening it with a knife; use a cap crimper.

DON'T prime both ends of a cartridge when making primers of half-cartridges, before cutting it in two. Cut the cartridge in half and prime each piece separately.

DON'T prime a dynamite cartridge, or charge or connect bore holes for electric firing during the immediate approach or progress of a thunder-storm.

DON'T attempt to use electric blasting caps with the regular insulation in very wet work. For this purpose secure du Pont Waterproof Electric Blasting Caps.

DON'T worry along with old, broken leading wire or connecting wire. A new supply won't cost much and will pay for itself many times over.

DON'T handle safety fuse carelessly in cold weather, for when cold it is stiff and breaks easily.

DON'T store safety fuse in a hot place, as this may dry it out so that uncoiling will break it.

DON'T lace safety fuse through dynamite cartridges. This practice is frequently responsible for the burning of the charge.

DON'T cut the safety fuse short to save time. It is a dangerous economy.

DON'T operate blasting machines half-heartedly. They are built to be operated with full force. They must be kept clean and dry.

DON'T expect a cheap article to give as good results as a high-grade one.

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